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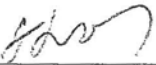
Phone Numbers

Commercial: 301-295-9474
Toll Free: 800-772-1747
DSN: 295-9474
FAX: 301-295-6772

Title of Thesis: "Attention Training in Smokers: A Feasibility Study
of an Ecological Momentary Assessment Approach"


Name of Candidate: William F. Kerst
Clinical Psychology
Master of Science
December 28, 2010

Thesis and Abstract Approved:



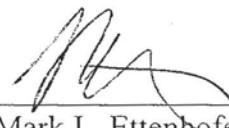
Andrew J. Waters, Ph.D.
Department of Medical and Clinical Psychology
Thesis Advisor

1/4/11
Date



Marian Tanofsky-Kraff, Ph.D.
Department of Medical and Clinical Psychology
Committee Member

1/4/11
Date



Mark L. Ettenhofer, Ph.D.
Department of Medical and Clinical Psychology
Committee Member

1/4/11
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A handwritten signature in dark ink, appearing to read 'W. F. Kerst', with a stylized, flowing script.

William F. Kerst, 1st Lt, USAF
Clinical Psychology Graduate Program
Uniformed Services University

TITLE: Attention Training in Smokers: A Feasibility Study of an Ecological
Momentary Assessment Approach

BY: William Kerst, B.A.

2010

DIRECTED BY: Andrew J. Waters, Ph.D.

Associate Professor, Medical and Clinical Psychology

ABSTRACT

Attention retraining (AR) is a novel potential treatment for tobacco dependence. AR trains smokers to attend away from smoking cues. Ordinarily AR has been delivered in the lab. We tested the feasibility of delivering AR on a PDA in the field. Smokers (N=12) were randomly assigned to an AR group or control (no training) group. They carried around a PDA for one week. They were prompted to complete 4 assessments per day, including 3 AR (AR group) or control tasks (control group). One PDA malfunctioned. Participants completed 196 of 255 (77%) of presented assessments. Training assessments lasted 10.27 minutes on average. Participants reported that they were not interrupted on the majority (69.4%) of assessments. The data suggested that AR appeared to have the intended effect on attention. This pilot study is the first to show that it is feasible to deliver cognitive training on a PDA in ecologically valid settings.

Attention Training in Smokers: A Feasibility Study of an Ecological Momentary
Assessment Approach

BY

WILLIAM KERST

Proposal submitted to the Faculty of the
Department of Medical and Clinical Psychology
Graduate Program of the Uniformed Services University
of the Health Sciences in partial fulfillment of the
requirements for the degree of Master of Science

2010

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Introduction

Cigarette smoking accounts for 443,000 deaths in the United States annually (Centers for Disease Control (CDC), 2007; 2010). Despite the apparent danger of cigarette smoking, a reported 20.6% of adults in the United States continue to smoke cigarettes (CDC, 2007; 2010). Nationally, in the United States, more men (23.9%) than women (18.0%) smoke. Smokers are more likely to have a lower level of education and lower socioeconomic status (CDC, 2007; 2010). In short, cigarette smoking is harmful to the smoker's health and yet remains widespread.

Smoking Cessation

The majority of smokers are motivated to quit (CDC, 1996). However, most quit attempts end in failure (Hughes et al., 1992; Cohen et al., 1989). Relapse to smoking is often rapid, with many relapses occurring in the first few days (Garvey, Bliss, Hitchcock, Heinold, & Rosner, 1992). Medications such as nicotine replacement and bupropion can improve cessation outcomes (Silagy, Lancaster, Stead, Mant, & Fowler, 2004; Jorenby, Leischow, Nides, et al. 1999). However, even with treatment, the majority of cessation efforts fail. Increased understanding of the psychological processes involved in smoking relapse may contribute to the development of better methods of promoting sustained abstinence in smokers wishing to quit.

Automatic and Controlled Psychological Processes

The psychological processes that underlie relapse remain unclear. It has long been noted that smokers experience acute discomfort when abstaining. It seems reasonable to suggest that smokers may therefore relapse simply to avoid this

uncomfortable state (the so-called “withdrawal-relief” hypothesis; Hughes, 2007). However, empirical studies have, in general, not provided strong support for the simple withdrawal-relief account. Most importantly, the association between severity of withdrawal and cessation outcome has been reported to be either somewhat weak or non-existent (Hughes, Higgins, & Hatsukami, 1990; Patten & Martin, 1996). Moreover, day-to-day changes in stress and affect do not seem to be associated with relapse risk in the first few weeks of a quit attempt (Shiffman & Waters, 2004). Finally, many relapses occur when participants report being in a neutral or positive mood (Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996). This finding seems to contradict the notion that smokers relapse in order to avoid an unpleasant state.

Recently, there has been growing interest in the cognitive processes underlying addiction and relapse (e.g., Wiers & Stacy, 2006). Researchers in cognitive psychology have described two types of cognitive process: controlled (or “explicit”) processes, and automatic (or “implicit”) processes (e.g., Schneider & Shiffrin, 1977). Controlled processes have the following characteristics: they are typically slow, serial, effortful, and driven by a conscious appraisal of events. Controlled processes may be measured reasonably well by self-report (questionnaire) measures. In contrast, automatic processes have an opposite set of characteristics: they are fast, parallel, effortless, and may not engage conscious awareness. Most researchers agree that automatic processes cannot be comprehensively assessed using questionnaires, but can be assessed using computerized cognitive tasks derived from experimental cognitive psychology (e.g., Waters & Sayette, 2006).

Attentional Bias

Starting with Tiffany (1990), a number of addiction researchers have stressed the potential role of automatic processes in drug addiction (Robinson & Berridge, 1993; Stacy, 1997; Wiers & Stacy, 2006). Perhaps the most widely studied automatic process in the addictions is automatic attentional capture by drugs and drug-related cues (termed “attentional bias”) (Cox, Fadardi, & Pothos, 2006). The importance of attentional bias (AB) is made most explicit in Robinson and Berridge’s (1993) incentive-sensitization theory (IST) of addiction. In IST, it is argued that mental representations of stimuli consistently paired with pleasure become the targets of incentive salience. These so-called “incentive stimuli” become attractive and wanted and “grab attention” (Robinson & Berridge, 1993, p. 261). Incentive salience is typically only assigned to the mental representations of those stimuli that are consistently paired with pleasure. However, in IST it is argued that drugs can cause the attribution of incentive salience to drug-related stimuli independently of any effect on the pleasure system. In some individuals, the effect of the drug (on salience attribution) becomes more pronounced over time (i.e., sensitization occurs). In those individuals, drug-related cues automatically attract attention and exert a strong influence over behavior. This excessive attentional bias has been considered an important component of dependence (e.g., Franken, 2003). For example, it has been suggested that excessive attentional bias contributes to increases in craving that, in turn, contributes to excessive attentional bias (Franken, 2003). In this model, attentional bias and craving form a reciprocal and cyclical relationship that contributes to increased risk of drug use and/or relapse.

Attentional bias can be assessed using a number of cognitive tasks including the visual probe (VP) task (e.g., Field & Eastwood, 2005), the modified Stroop task (e.g., Waters, Shiffman, Bradley, & Mogg, 2003), and the attentional blink task (e.g., Waters, Heishman, Lerman, & Pickworth, 2007). Some studies have reported that attentional bias prospectively predicts outcomes in the addictions (e.g., Carpenter, Schreiber, Church, & McDowell, 2006; Cox, Hogan, Kristian, & Race, 2002; Janes et al., 2010; Marissen et al., 2006; Waters et al., 2003b). Therefore, interventions that reduce attentional bias may improve treatment outcomes in the addictions.

Visual Probe Task

The visual probe (VP) task has been used to assess the automatic allocation of visual attention. This task is premised on the finding that individuals, when asked to respond quickly to the presentation of a probe, will do so faster if that probe is in an attended position than if it is in an unattended position (Posner, Snyder, & Davidson, 1980). The VP task utilizes this finding to test differences in automatic attention capture between two stimuli, usually one salient and one neutral. In this task, participants' eye gaze is first directed towards a central fixation point briefly, followed by the brief (usually 500 ms) presentation of a word or picture pair, one to the left of the fixation point and one to the right. After the presentation of the stimuli, one of the images/words is replaced by a probe to which the participant must respond as quickly as possible. Participants' reaction times to probes are recorded.

A typical finding is that individuals are faster to respond to probes that replace motivationally salient stimuli than probes that replace motivationally neutral stimuli (Mogg & Bradley, 1998). This finding is interpreted as indicating that attention has

shifted toward the motivationally salient stimulus (i.e., there is an “attentional bias” to the salient stimulus). In the past 25 years, numerous studies have used the VP task to demonstrate attentional biases in a range of psychopathologies, including anxiety (e.g., MacLeod, Mathews, & Tata, 1986), eating disorders (e.g., Cooper, Anastasiades, & Fairburn, 1992), and drug addiction (e.g., Lubman, Peters, Mogg, Bradley, & Deakin, 2000), as well as tobacco addiction (e.g., Waters & Sayette, 2006).

Attentional Retraining (AR) in Anxiety

Most research in experimental cognitive psychopathology has used tasks such as the VP task to assess the cognitive processes that underlie psychopathology. However, in the past few years there has been increasing interest in developing interventions that directly target automatic/implicit processes, such as attentional bias (e.g. Mathews & MacLeod, 2002). The basic notion is as follows: the typical experimental cognitive tasks used to assess implicit processes are modified in such a way that they can change implicit processes. Participants are asked to complete several trials of these modified tasks after which investigators test to see what effect the completion of these modified tasks have had on the automatic processes under investigation. Usually the standard version of the task is used to assess change in the implicit processes. Furthermore, the investigators will also use self-report and behavioral outcome measures to examine the effect of the intervention on other outcome variables.

Much of the original successful research done in this area was done by Colin MacLeod, Andrew Mathews, and their colleagues. MacLeod’s group used a modified

version of the VP task in an attempt to alter participants' AB toward threat stimuli. MacLeod and colleagues termed this form of cognitive bias modification, „attentional retraining" (AR). The VP task used first by MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) was modified such that the probe replaced the neutral stimuli on 100% of trials in one group of participants (attend-neutral condition) and the probe replaced the threat stimuli on 100% of trials in a second group of participants (attend-threat condition). The authors used extensive numbers of training trials (576) in the modified version of the VP task. Participants were non-anxious undergraduate students.

There were two important results in this seminal study of AR. First, AR influenced attentional bias to negative stimuli, as assessed by the standard VP task (MacLeod et al., 2002). Participants in the attend-negative condition tended to be faster to respond on trials in which the probe replaced negative words. Participants in the attend-neutral condition tended to be faster on trials in which the probe replaced neutral words. Thus, the AR did significantly influence attentional bias. This was true even for new material (negative and neutral words that were not included in training trials). Second, participants assigned to the attend-neutral condition reported significantly less anxiety and depression on a subsequent stressor task (an anagram stress task) compared with those in the attend-negative condition. Using similar procedures, Hazen, Vasey, and Schmidt (2008) also demonstrated that AR could lead to changes in self-reported anxiety.

In a follow up study, MacLeod and colleagues delivered AR via the internet (See, MacLeod, & Bridle, 2009). Participants were Indonesian young adults

preparing to relocate to Australia for school. The relocation was viewed as an actual and salient stressor. Half the participants were trained to attend away from negative information and toward neutral information (attend-neutral). Half were assigned to a control (no attentional training) condition. After 15 days of AR or control training, the students relocated. At that time, they reported their levels of state and trait anxiety. Levels of state and trait anxiety were both lower in the attend-neutral group than in the control group. Importantly, the data suggested that attentional bias progressively increased (toward neutral stimuli and away from negative stimuli) over the 15-day training period in the attend-neutral group. This suggests that additional “doses” of AR may have greater effects on attentional bias.

AR in Addiction

The success of AR in the anxiety literature has motivated researchers to apply AR as an intervention for addictions. In particular, researchers have attempted to reduce or reverse attentional bias to drug cues. **Table 1** summarizes the pertinent published studies. Using a modified VP task, Field and Eastwood (2005) randomly assigned heavy social drinkers to an attend-alcohol condition (probe always replaced alcohol stimuli) or an avoid-alcohol condition (probe always replaced neutral stimuli). After AR, the magnitude of attentional bias to alcohol-related stimuli, assessed on a standard VP task, was significantly increased in the attend-alcohol group, but was significantly decreased in the avoid-alcohol group. Finally, after AR, participants were given the opportunity to drink some beer. The attend-alcohol group consumed significantly more beer than the avoid-alcohol group.

In a follow-up study, Field et al. (2007) replicated the finding that AR could significantly influence attentional bias on the standard VP task in drinkers. However, the effects of AR did not generalize to a different attentional bias task (alcohol Stroop task). Moreover, there was no effect of AR on self-reported craving or alcohol consumption. Similarly, Schoenmakers, Wiers, Jones, Bruce, and Jansen (2007) also reported that AR could influence attentional bias in a group of heavy drinkers. However, AR did not influence self-reported craving or performance on a behavioral measure of alcohol use.

Fadardi and Cox (2009) reported an AR intervention for hazardous and harmful alcohol drinkers (defined by U.K. National Health Service standards). The AR was delivered as part of what the authors called an Alcohol Attention-Control Training Program (AACTP). The AACTP includes a trainer and a trainee. The trainer encourages the trainee to improve his or her reaction times to neutral stimuli. The AR task used was a modified pictorial Stroop with images of alcohol and neutral stimuli presented with a colored background to which the participants must respond. In sample two of the study hazardous drinkers underwent one week of AACTP training (two sessions separated by one week). Attentional bias to alcohol cues decreased as a result of training and the heaviest drinkers reported an increase in motivation to change their drinking behavior. In sample three of the study, harmful drinkers underwent four weeks of the AACTP training (four sessions each separated by one week). Attentional bias to alcohol cues decreased as a result of training and this decrease was maintained at a three month follow-up. Also, a decrease in

alcohol consumption was reported as the result of training and maintained at three month follow-up.

A recent AR study used a modified VP task in smokers (Attwood, O'Sullivan, Leonards, Mackintosh, & Munafo, 2008). Attentional bias, assessed on a standard VP task, increased in an attend-smoking condition and decreased in an avoid-smoking condition. Subsequent cue reactivity (craving after handling a lit cigarette) was reduced in the avoid-smoking group; however, this effect was only significant in males.

The most recent study of attentional retraining by Field's group is a study of attentional retraining in a sample of cigarette smokers (Field, Duka, Tyler, & Schoenmakers, 2009). The investigators used a modified VP task with pictures to retrain attention in cigarette smokers. Participants were randomly assigned to one of three groups. In one group participants were trained to attend toward smoking cues and away from neutral cues. In a second group, participants were trained to attend toward neutral cues and away from smoking cues. In the third group, participants' attention was not manipulated (e.g. they completed a standard VP task). Attentional bias towards smoking cues, as assessed with the VP task, increased in the attend-smoking condition only on trained stimuli (stimuli used for the retraining portion) over time. Attentional bias on trained stimuli decreased in the attend-neutral condition and the control condition over time. However, no changes in attentional bias were noted for novel stimuli (stimuli not used in the training) on the VP task. In addition, training had no effect on attentional bias assessed with the pictorial Stroop. No other significant effects were found.

To the best of our knowledge, Attwood et al. (2008) and Field et al. (2009) are the only published studies that have applied AR in smoking. A limitation of both these studies is that AR occurred in a single training session. Thus, the effect of more intensive AR in the context of smoking is not known. For example, other forms of cognitive retraining, such as executive function retraining, often require multiple sessions to be effective (i.e., Klingberg, Forssburg, & Westerberg, 2002). Similarly, AR may require many sessions in order to be maximally effective. This may be particularly so when attempting to train smokers to attend away from smoking cues, given that their preferred response would be to attend toward smoking cues.

Summary of AR literature

To summarize, modified VP tasks can be used to influence attentional bias (assessed on a standard VP task). Studies have reported that AR can modify attentional bias to both threat-related (e.g., Mathews & MacLeod, 2002; See et al., 2009) and drug-related stimuli (e.g., Field & Eastwood, 2005; Field et al., 2007). Moreover, some studies have reported that AR can influence self-report and behavioral outcomes. For example, MacLeod, et al. have reported that participants assigned to an attend-neutral (avoid-negative) condition reported less anxiety when subsequently exposed to a laboratory (MacLeod et al., 2002) or real-world stressor (See et al., 2009). Two laboratory studies have applied AR to smoking with mixed results. However, both of these studies involved only single-sessions. Thus, the effect of more intensive AR on smoking is not known.

Ecological Momentary Assessment (EMA)

Researchers have hitherto administered AR in a laboratory setting or over the Internet. Ecological momentary assessment (EMA) may be a useful method for extending the scope of AR and for examining its effects on attentional bias. EMA involves assessing phenomena at the moment they occur (hence, “momentary”) in a person’s natural environment (hence, “ecological”). Assessments may be done at random times (“random assessments”; RAs), or when participants experience heightened emotions (e.g., feeling particularly stressed). A combination of these random and event sampling strategies can be used (e.g., Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996). In the past two decades, EMA has been an increasingly influential methodology in addiction research, particular tobacco addiction (e.g., Shiffman & Waters, 2004; Shiffman et al., 2008).

Recent advances in EMA data collection have utilized small hand-held computers (PDAs). These devices allow for the preprogrammed prompting of participants to enter data. They can be programmed to prompt participants either randomly or according to an existing schedule. There are many benefits to using PDAs to collect EMA data such as the close monitoring of compliance by time stamped data entry on the PDAs (Stone and Shiffman, 2002). Also, by using PDAs computerized reaction time tasks can be administered (Shiffman et al., 1995; Waters & Li, 2008).

Thus, in the current context, EMA provides a potentially useful method for both administering AR (e.g., using the modified VP task) and for assessing changes in attentional bias over time (e.g., using the standard VP task).

It is important to note that if AR administered via a PDA were shown to be effective, it could potentially be delivered to participants when they are most in need of this intervention (i.e., when attentional bias is elevated). Thus, PDAs may provide a method by which momentary interventions (“ecological momentary interventions”) could be delivered.

Rationale

In the current study, we administered AR, using the modified VP task, on a PDA. By using this approach, we intended to deliver a greater number of doses of AR than have been administered in previous studies. More doses of AR may lead to greater reductions in attentional bias (See, et al., 2009) and, perhaps, more robust effects on craving and smoking behavior. Administering AR in the smokers’ natural environment may also facilitate the transfer of AR from the training setting to a real world setting. As noted above, in addition to delivering AR (on the PDA), we also assessed attentional bias (on the PDA), using the standard VP task. This allowed us to track changes in attentional bias over time.

Studies

There were two studies, a pilot study and a main study. The pilot study is reported here. The pilot study (N = 12) was primarily a feasibility study. Specifically, we tested the feasibility of administering AR on a PDA in an EMA study. Feasibility was evaluated in four ways. First, we tested the hardware and software used to administer the AR on the PDAs. Second, we estimated compliance to study procedures (e.g., response rates to RAs). Third, to assess the assessment burden

we evaluated the duration of training assessments. Last, we assessed the proportion of occasions in which participants were disturbed during task performance.

In addition to assessing feasibility, we also present descriptive statistics of the study data. Specifically, we used the preliminary data to estimate the effect size for the effect of AR on the primary outcome variable (attentional bias) as well as other study variables.

Research Design and Methods

Participants

Participants were 12 adult community-based smokers in the Washington D.C. metropolitan area. Participant recruitment was accomplished by advertising for smokers age 18 – 65 years in a local newspaper, Craigslist.com, and through the use of flyers. Participants were paid \$20 for each of two laboratory visits as well \$5 per day that they contributed data to the study up to a maximum of 7 days. They also received \$2 for each RA that they completed. To qualify, participants had to smoke 10 or more cigarettes per day for the past two years, and be aged 18 – 65 years. If they were a federal civilian or member of the military they had to have their supervisor's approval for participation. Exclusion criteria included expired breath carbon monoxide levels lower than 10 parts per million (ppm) or any other factor that, in the judgment of the investigators, would likely preclude completion of the protocol.

Demographic and baseline data for participants who completed the pilot study and provided usable data are presented in **Table 5**. Demographic data were collected via self-report at the first laboratory session. Fifty-six percent of the

participants were male. Seventy-seven percent were African-American, 11% Caucasian, and 11% Other.

Development of VP task on PDA

The pilot study tested the software and hardware used to deliver AR in an EMA setting. Software programs exist to administer AR on desktop computers. However, to extend AR out of the laboratory and into real life, custom software was developed to administer AR in an EMA paradigm. Because the VP task has been the primary method of delivery of AR in previous studies (e.g., MacLeod et al., 2002; see also **Table 1**) it was determined that the VP task would be the most appropriate method of administering AR in this study.

To develop the software required to deliver AR we had to add to the existing software platform the capability to administer the VP task. The software used in our previous studies (e.g., Waters & Li, 2008; Waters, Miller, & Li, 2010) was developed to administer other reaction time tasks such as the Implicit Association Test and the modified Stroop task. Both of these tasks use a typical portrait page orientation (**Figure 1-A**). However, given the limited left to right physical separation of the stimuli in portrait mode, we reconsidered the method of task presentation. Holding the PDA in landscape orientation would increase the stimuli size and separation possible for the VP task. As can be seen in **Figure 1**, landscape mode also allows for larger images with an additional 95mm of separation between the center of the left side and the center of the right side of screen, where the images are to be presented. In this study, the onscreen display is 7.3 cm x 5.4 cm with a resolution of 320 pixels x 240 pixels. The images used in landscape mode are 113 pixels x 113

pixels. In landscape mode, the distance from the centers of left and right sides of the screen is 3.65 cm.

In **Figure 1** the visual angle of separation between the centers of the images can be compared in portrait mode and in landscape mode. These angles are calculated with a typical hand-held device viewing distance of 35 cm (Kato, Boon, Fujibayashi, Hangai, & Hamamoto, 2005). Presenting the stimuli in portrait mode allows for a visual angle between the centers of the displayed images (the location where visual probes are displayed) of 4.42° while in portrait mode and the visual angle is 5.98° while in landscape mode. Previous research using the visual probe task in a desktop computer has reported a 5.4° visual angle of separation between visual probes (Field, Mogg, & Bradley, 2004; Mogg, Bradley, Field, & De Houwer, 2003). In our study, landscape mode allows for a visual angle between probe positions consistent with previous desktop eye tracking studies.

However, the hand-held device used in this study (Compaq iPaq) does not have landscape display functionality. To overcome this challenge the software programmers made images of all on-screen displays and rotated them 90° to allow for operation in a „virtual“ landscape mode. The virtual landscape mode was only used for the presentation of stimuli in the VP task. Upon initiation of a random assessment, self-report questions on context and affect were presented in portrait mode. Upon the conclusion of the self-report items, participants were required to rotate the PDA 90° in their hands to complete the VP task in a landscape orientation.

Of course, rotating the screen 90° to administer the VP task introduced new challenges for programming. For example, whilst in portrait mode, the hard-wired

buttons are easily available to both of the participant's hands because the buttons are at the bottom of PDA. However, when rotating the PDA 90° clockwise, all hard-wired buttons are now on the far right disallowing the use of the left hand in responding to cognitive tasks. For this reason the programmers created two virtual buttons that would operate via the touchscreen to allow participants to interact with the PDA during the cognitive task by using their thumbs to press on-screen buttons via the on-board touchscreen (**Figure 2-3**). Reaction times were recorded by the PDA to the nearest millisecond as in our previous studies with other reaction time tasks (i.e., Waters & Li, 2008).

Procedures

Recruitment for pilot participants took place 7/28/09 through 10/13/09. In the pilot study, 37 individuals were screened over the telephone, 29 were eligible based on the telephone interview, 27 made an appointment for the orientation visit, 14 attended orientations, 12 were eligible at orientation, and, as noted above, 12 were enrolled in the study. Participants in the pilot study completed all of the procedures described below, including both lab visits and 7 days of AR (or control training) delivered via PDA.

Session #1. **Figure 3** provides the timeline for the study. Participants first contacted the researchers by leaving a phone message expressing interest in the study and leaving their contact information. Research staff returned participants' phone calls and conducted a telephone screening to ensure the participants met criteria for inclusion. If a participant was eligible to participate in the study they were invited to attend an initial orientation session. If the participant was eligible, this visit also served

as the first laboratory visit. At this first laboratory visit, study personnel provided a detailed description of the study, answered questions, confirmed eligibility, and obtained written informed consent (see Appendix B). Individuals who declined to participate or were ineligible were given self-help materials and a referral to smoking cessation programs (if interested).

Next, participants were asked to provide a breath sample by blowing through a carbon monoxide (CO) monitor. If the CO monitor indicated that a participant's expired CO level was very low (less than 10 ppm), he or she was excluded from the study. This is because, if the participant's expired CO level is indeed below 10 ppm, there is serious doubt as to whether the individual actually smoked at a rate of 10+ cigarettes per day (Society for Research on Nicotine and Tobacco Subcommittee on Biochemical Verification, 2002).

After signing the consent form, the participant was randomly assigned to the AR or control condition according to a randomization list that was stratified by sex. Both the participant and the research assistant were blinded to condition assignment. The participant then completed the VP task on the PDA in the laboratory.

Participants also provided a saliva sample for analysis of cotinine levels. (Cotinine is a metabolite of nicotine.) Participants then completed a demographic questionnaire, a smoking history questionnaire, the Fagerstrom Test for Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991), the Balanced Inventory for Desirable Responding (BIDR) (Paulhus, 2006), and the Questionnaire for Smoking Urges (QSU) (Tiffany, 1997) using the Questionnaire Development System (QDS) computerized questionnaire delivery system. At the

conclusion of the first laboratory session participants were given a smoking diary. They were asked to make an entry each day before they went to bed indicating how many cigarettes they smoked on that day. Participants were told that they could smoke as much or as little as they like during the week. These diaries were collected from the participants at the second laboratory session.

Participants were trained on the use of the PDA at the end of the first laboratory visit. All EMA procedures were implemented on a HP iPAQ running the Microsoft Windows Pocket PC operating system. Application programming was done in C#.NET by Terminal C, a Houston-based company. The PDA uses a stylus-based, touchscreen system and is user-friendly. Participants navigate through the software and enter data simply by touching the stylus or their finger to the screen. Participants completed EMA questions in the same way as they would a pen-and-paper questionnaire (i.e., using the stylus to mark the appropriate answer). There is no keyboard and only a few external buttons. To use the program participants did not need to possess any computer skills or know how to type. As in our ongoing studies, participants were locked out of all functions other than our program. Thus, other programs could not confuse them. Furthermore, this renders the PDAs are essentially worthless for anything but delivering the study application. Because of its small size (i.e., roughly equivalent in size to a pack of cigarettes), the PDA is easy to carry in a shirt pocket or purse. Participants were offered use of an additional carrying case to protect the PDA and to facilitate their carrying the PDA at all times. **Table 2** lists all study procedures and measures.

The EMA procedures. In the EMA portion of the study participants carried the PDA around with them as they went about their daily lives. The PDA was programmed

to prompt the participants at random times four times per day (random assessments (RAs)). Three of the RAs involved completing an AR task (for those in the AR condition) or a control task (for those in the control condition). One RA per day involved completing a standard VP task (all participants). At each assessment the participant first completed questions assessing their current state using self-report measures.

Session #2. After one week participants returned to the laboratory with their PDA for the second and final laboratory visit. At this session the participants again completed the standard VP task. They also completed the QSU, provided a breath sample for CO analysis, and a saliva sample for cotinine analysis. Participants then completed the mobile eye tracking portion of the study (see measures).

Training Conditions (Table 3)

AR condition. Participants in the AR condition were scheduled to complete 3 modified VP (AR) tasks and 1 standard VP task per day on the PDA. The standard VP task was scheduled to be presented on the final RA of the day. Thus, it was scheduled to occur after 3 AR tasks. On the AR tasks, the dot always replaces the neutral picture. Thus, there is a perfect correlation between picture type and dot location. In other respects, the AR task is same as the standard VP task. The number of trials on the AR tasks (160) was determined after internal piloting to fit with the capabilities of the software we used (must be multiples of 80) and the need to maximize training trials.

Control condition. Participants in the control condition were scheduled to complete 3 control tasks and 1 standard VP task per day on the PDA. As with the AR condition, the standard VP task was scheduled to be presented on the final RA of the day. Thus, it was scheduled to occur after 3 control tasks. On the control task, the dot is

equally likely to replace the smoking picture and the neutral picture. Thus, there is no correlation between picture type and dot location. This type of control condition has been used in previous AR studies (e.g., Field et al., 2007). The control task consisted of 160 trials. This control condition ensures that: 1) the duration of each PDA assessment (and therefore study burden) should not differ between groups; 2) the AR and control participants receive equal practice over the course of the study on the motoric aspects of the VP tasks (pressing the buttons); and 3) the same smoking and neutral pictures are presented with equal frequency to the AR and control participants over the course of the study. Note that, aside from the number of trials, the control task is the same as the standard VP task.

Measures

Visual Probe Task. Participants were instructed that a dot would be presented on the left or right hand side of the PDA screen. They were required to indicate the position of the dot as quickly as possible by pressing a “Left” or “Right” button on a PDA screen using their thumbs (**Figure 2**).

The standard VP task was based on that used by Waters, et al. (2003). It consisted of 80 experimental trials, presented in a new random order for each assessment. At the start of each trial, a fixation cross was displayed in the center of the screen for 500 ms. The picture pair was then be presented for 500 ms, one picture on each side of the central position. The dot probe was displayed immediately after the offset of the pictures (see **Figure 2** for a sequential diagram of the task). It remained on the screen until the participant made a response. After the participant responded, the fixation cross for the subsequent trial was presented.

As previously noted, there were two versions of the VP task. In the AR or control tasks there were 160 trials presented. However, in the assessment task there were 80 trials presented. Each picture pair was presented 16 times in AR or control tasks and 8 times in the assessment tasks. Each smoking-related picture appeared once in each of four conditions, reflecting the combination of two within-subject variables of picture location (smoking-related picture on the left versus right of the screen), and probe location (probe on left versus right of screen). Thus, on half the trials, the probe replaced the smoking pictures, and on the other half, the probe replaced the neutral picture.

Reaction times were computed from trials with correct responses. To reduce the influence of reaction time outliers (see Ratcliff, 1993), reaction times less than 100 ms were discarded, and the median RT was used as a measure of central tendency in each condition (probe replacing smoking picture vs. probe replacing neutral picture). We computed AB index scores as the difference in RTs on trials where the probe replaced the smoking picture vs. trials where the probe replaced the neutral picture. Faster RTs on the former reflects an attentional bias towards to the smoking picture, or vigilance. Faster RTs on the latter reflects an attentional bias away from the smoking pictures, or avoidance. This formula yields an attentional bias index score with high (positive) values corresponding to an attentional bias toward smoking stimuli and a low (negative) values corresponding to an attentional bias away from smoking stimuli and toward neutral stimuli.

Laboratory self-report measures. **Appendix A** lists the self-report measures used in this study. Laboratory self-report measures included a demographics questionnaire

which asked participants to provide their age, sex, race/ethnicity, income, and other demographics data. The smoking history questionnaire contained questions relating to the participants' current and past smoking behavior. Questions include how long they have been smoking, how much they smoked on average, and what kind of cigarettes they smoked (i.e. menthol or regular).

The Fagerstrom Test of Nicotine Dependence (FTND) is widely-used a self-report measure of nicotine dependence. It yields scores that range from 0 – 10 with greater values reflecting greater dependence (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991).

The Balanced Inventory of Desirable Responding (BIDR) is a self-report measure of socially desirable responding (Paulhus, 1988). Data from the BIDR is not presented in the current report.

The Questionnaire for Smoking Urges (QSU) is a self-report measure of craving (Cox, Tiffany, & Christen, 2001). The 10-item QSU yields two factor scores: Factor 1 captures intention and desire to smoke and anticipation of pleasure from smoking, and Factor 2 reflects anticipation of relief from negative affect and nicotine withdrawal and urgent need to smoke. A total score can also be computed, and the total score is reported in the current study.

Biological measures. Cotinine is the primary metabolite of nicotine, and because it has a long half-life (around 17 hours), it can measure the intake of nicotine over the few days before the assessment. It is the principal measure used to validate self-reported abstinence and is considered the “gold standard” for measuring nicotine exposure (SRNT Subcommittee for Biochemical Verification, 2002). The sensitivity and

specificity levels are over 90% (Ossip-Klein, et al., 1996). Salivary cotinine levels were measured through an immunoassay conducted by Salimetrics, LLC in State College, PA.

Exhaled CO levels were measured with a CO monitor (Vitalograph, Lexena, KS). CO levels provide an additional measure of exposure (SRNT Subcommittee for Biochemical Verification, 2002). The participant's CO level was obtained at the beginning of each experimental session. The CO monitor was calibrated from a cylinder of research gas with a known CO concentration (about 50 ppm) regularly.

PDA self report assessments. Participants responded to the following items on 7-point Likert-type scales (1 = Strongly Disagree, 7 = Strongly Agree) according to how they feel "right now": 1) Craving - One item assessed craving for cigarettes; 2) Difficulty concentrating - One item evaluated difficulty concentrating (Shiffman et al., 1996); 3) Affect - Items included: enthusiastic, happy, relaxed, bored, sad, angry, two additional items assessed overall mood and energy/arousal levels; 4) Anxiety - A 6-item version of the STAI (upset, worried, frightened, calm, secure, self-confident) assessed state anxiety (Sayette, Martin, Wertz, Perrott, & Peters, 2001); 5) Hunger - One item assessed the degree of hunger. In addition, 3 items assessed testing and lighting conditions (e.g., whether they were currently indoors or outdoors); 2 items assessed context (whether participants were alone or with others, and whether they were at home/work/ in transit/at a bar or restaurant/somewhere else). Items assessed the number of cigarettes smoked so far that day (Response options: No cigarettes/At least one cigarette), the recency of the last cigarette smoked (More than 2 hours ago/Between 2 hours and 30 minutes ago/ Less than 30 minutes ago/ Just smoked or

smoking now), the amount of alcohol consumed in the past 2 hours (Drank no alcohol; Drank a little alcohol; Drank a lot of alcohol), and the amount of coffee consumed in the past 2 hours (Drank no coffee; Drank a little coffee; Drank a lot of coffee).

After the VP task, an item asked how many times the participants was interrupted while performing the task (e.g., by the telephone ringing or by somebody trying to talk to them) (No times/1 time/2 times/3 times/4 or more times).

We also included a second craving item that assessed craving in response to smoking pictures. Specifically, on each PDA assessment, a smoking picture with neutral features (see **Figure 4** for an example) was presented for 1 second. Participants subsequently reported their craving on a 1-7 scale. The rationale for including this additional craving item was as follows. If AR causes attention to be drawn to neutral stimuli in the picture (as is hypothesized), then “exposure” to the smoking cue should be reduced and therefore there should be less cue-induced craving.

Sequence of events during an individual PDA assessment. Upon prompting by the PDA the participant initiated the RA. The first assessment was the cue provoked craving measure. So, after an assessment was initiated an image containing smoking (and neutral) stimuli was displayed on the PDA screen for 1 second. Thereafter the craving question was presented. After the cue-provoked craving measure the self-report questions were presented. As noted above, they assessed mood, state, and context. (One of these questions was the second (non-cue-provoked) craving question).

Following the self-report items, instructions for completing the VP task were presented on the PDA screen. The instructions were immediately followed by the VP task (AR task, Control task, or standard VP assessment). At the conclusion of the VP

task the participant was asked how many times he or she was interrupted while performing the task.

Mobile Eye Tracking. For this study the A-S-L (Applied Science Laboratories) Mobile Eye system was used. It is a tetherless, compact eye tracking system. The eye tracking optics are lightweight and unobtrusive. They include a spectacle mounted mini camera and monocle that reflects a cornea image illuminated by infrared LEDs to capture eye gaze relative to a scene video captured by a second spectacle mounted mini camera. The resolution of the scene video recorder is 640 X 480 pixels with a 60° horizontal field of view. The recording device is small and lightweight and is worn on a hip pack. The eye image and scene image are interleaved and saved on a DVCR tape. The video is then transferred to a password protected laptop where it is saved as a digital video for later analysis using GazeTracker software specially designed for analyzing mobile eye tracking data. The image is separated and a scene video can be created with a variable cursor overlay. The gaze location is recorded at close to 30 Hz and mapped to the 640 X 480 pixel display scene video. This combination of data allows for comparison between the scene video and the relative gaze location. The A-S-L Mobile Eye has been used in a number of research and military settings.

A participant was first fitted with adjustable glasses in the cognition lab (28-101). The eye tracking system was individually calibrated for each participant. After calibration, the researcher led the participant into another room used as a smoking laboratory (28-102). The researcher told the participant that he or she (the researcher) needed to complete setting up a task in the cognition lab (28-101). In 28-102 there was an unlit cigarette positioned in an empty ashtray with a lighter next to it. The

environment in this new room was the same for all participants. Other items in the room were neutral and included: a computer and monitor on a desk; an empty coffee mug; a small plant; an air purifier on the ground; a desk chair; a telephone; and artwork on the wall. The participant was seated in the chair and left alone in the room for 1 minute. During that time, the participant was obviously free to look around the room at his or her leisure. We assessed the time that the participant spent looking at the smoking stimulus and the neutral stimuli (any other areas in the smoking lab). If AR causes participants to attend away from smoking stimuli (as hypothesized), we would expect participants in the AR condition to gaze at the cigarette for a briefer duration than those in the control condition. The mobile eye assessment lasted about 6 minutes in duration (including calibration).

At the end of the second laboratory assessment, participants were debriefed about the purpose of the mobile eye assessment. Specifically, the researcher informed them: “As you know from the consent form, the purpose of this behavioral research study is to evaluate a new method of influencing smokers’ attention, cravings and smoking. When you wore the spectacle, we wanted to know at what you were looking. If one of the training conditions changes how your attention works, it may influence how long you spent looking at different objects in the smoking room or the order in which you looked at them. By measuring your eye movements we can test if the training conditions influenced this aspect of your attention”.

Stimulus Materials

Images used as stimuli were taken from the International Smoking Image Set (ISIS; Gilbert et al., 2007), previous published studies (Waters et al., 2007; Swanson,

Swanson, & Greenwald, 2001), and our own original images (taken using a digital camera). Images were selected for inclusion from an original pool of more than 300 images. The images were categorized based on both smoking-relatedness (smoking vs. neutral (nonsmoking)) and content (human vs. no human (nonhuman)). This grouping yielded 4 categories of images: human-smoking, human-neutral, nonhuman-smoking, nonhuman-neutral). The research staff then rated the overall quality of the image as a salient stimulus based on category (human-smoking, human-neutral, nonhuman-smoking, nonhuman-neutral) on a 0 (not good) – 5 (very good) scale (e.g. a good human smoking image). These ratings were then averaged across researchers for each image and the highest rated 20 images from each category were chosen for inclusion in the final set of 80 images. These 80 images (20 human-smoking, 20 human-neutral, 20 nonhuman-smoking, 20 nonhuman-neutral) were then randomly paired. Human-smoking images were paired with human-neutral images, and nonhuman-smoking images were paired with nonhuman-neutral images.

There were a total of 8 days that a participant would have the PDA (counting the two days of the laboratory visits). Therefore, there were 8 different image sets created. This was accomplished by first creating 40 randomly paired image sets. These were split into two sets of 20 image pairs. Then the same pool of 80 images were again randomly paired to create two more sets with 20 image pairs each (same images, novel pairing). Thus far we have 4 sets of 20 random image pairings. To create eight sets of image pairs we split each of the four existing sets of 20 image pairs in half to create 8 sets of 10 image pairs. These sets are lettered A through H in **Table 4**. They are shown

with 8 hypothetical participants to illustrate how participants were assigned random sequences of the 8 sets (A through H) over the 8 days of the study.

Each day of the study 10 image pairs of one set was used for both AR or control tasks and for the standard VP task to assess AB. Thus, eight sets of images were used during the week that the participants had the PDA, one set of 10 image pairs per day.

Figure 5 illustrates the creation of the 8 sets of 10 image pairings used in this study.

Data Reduction and Analysis

In this pilot study we focus on presenting descriptive statistics, rather than inferential statistics. We present means and standard deviations for all study measures (continuous variables). We present summary statistics aggregated over observations and aggregated over subjects. Overall, Control participants completed 86 PDA assessments (58 control training, 18 assessments) and AR participants completed 120 PDA assessments (93 AR training, 27 assessments). We explored the effect of time on EMA data by examining data from days 1-4 and from days 5+. Control participants completed 9 assessments during days 1-4 and 9 assessments from day 5+. AR participants completed 16 assessments during days 1-4 and 11 assessments from day 5+. Control participants completed 41 control trainings and assessments during days 1-4 and 35 control trainings and assessments from day 5+. AR participants completed 65 AR trainings and assessments during days 1-4 and 55 control trainings and assessments from day 5+. The rationale for exploring the effect of time was that we expected the effect of AR on attentional bias to increase over time (due to greater levels of training).

We used Cohen's d to estimate effect sizes. Cohen's d calculates effect size for sample data by dividing the difference in sample means by the pooled standard deviation. (Unequal sample sizes do not influence the denominator). To facilitate comparisons between effect sizes derived for field and laboratory data, all effect size estimates were computed on subject-level (not observational-level) data.

For mobile eye data we analyzed the data from the first five seconds as the participant walked into the experimental room. Data captured by the ASL Mobile-Eye tracking system was analyzed using GazeTracker software. Extracted data included a single "Look Zone" which was centered on the smoking stimuli. Data on all other areas of the visual display (captured by the spectacle mounted camera) were classified as neutral stimuli. **Figure 6** presents a screen shot of the experimental room to highlight the smoking cued look zone which is the area of interest and the neutral area of the visual display. Fixations were defined by the GazeTracker software as a minimum of 3 consecutively recorded points within a 40 pixel diameter area in the visual display for at least 200 ms. This is the default setting for GazeTracker and consistent with recommended practices for eye tracking in video (which is similar to mobile eye tracking with a dynamic visual area to track) (Ali-Hassan, Harrington & Richman, 2008).

Results

PDA Performance. Fourteen participants attended orientation, 2 of whom were ineligible due to low expired breath CO. Of the 12 eligible participants, 2 did not provide usable data for reasons other than software and/or hardware malfunction

(researcher error ($n = 1$) and loss of PDA by participant ($n = 1$)). Data from 1 participant (8.3%) were lost due to PDA error ($n = 1$),

Compliance. Over the course of the week, the participants that provided usable data ($N = 9$) completed 196 of 255 (77%) (95% CIs = 71.3%, 81.6%) assessments presented over an average of 7.44 ($SD = 0.73$) days. Control participants completed a mean of 19.3 ($SD = 0.58$) control trainings. AR participants completed a mean of 15.5 ($SD = 3.62$) AR trainings.

Assessment Burden. The mean duration of assessments ($n = 45$) was 6.18 minutes ($SD = 1.24$). The mean duration of Control training assessments was 9.93 minutes ($SD = 1.15$) and of AR training assessments was 10.6 minutes ($SD = 1.83$). Thus, if a Control or AR participant completed all 4 scheduled assessments in a day, the total expected burden would be approximately 36.0 and 38.0 minutes, respectively.

The mean number of minutes devoted to Control or AR training assessments throughout the study was 191.6 and 164.3 minutes respectively. The mean number of trials (on the modified VP task) devoted to Control or AR trainings throughout the study was 3088 and 2480 trials, respectively.

Interruptions. Participants reported no interruptions on 136 (69.4%) of PDA assessments. They reported one interruption on 22 (11.2%) PDA assessments, two interruptions on 18 (9.2%) PDA assessments, three interruptions on 14 (7.1%) PDA assessments, and four or more interruptions on 6 (3.1%) PDA assessments.

Field Data

Contextual Variables. Participants reported that they had smoked a cigarette so far that day on 139 (70.9%) of PDA assessments. On the other 57 (29.1%) PDA assessments they reported that they had yet to smoke a cigarette that day. Participants reported that they were indoors on 148 (75.5%) of PDA assessments. They reported being alone on 118 (60.20%) of PDA assessments. When asked where they were, participants reported that they were at home on 120 (61.22%) of PDA assessments, at work for 19 (9.69%), traveling for 36 (18.37%), at a bar or restaurant for 2 (1.02%), and somewhere other than the aforementioned locations on 19 (9.69%) of PDA assessments. Participants reported that they had drank no alcohol in the last two hours on 166 (84.69%) of PDA assessments, a small amount of alcohol on 22 (11.22%) of PDA assessments, and a large amount of alcohol in the last two hours on 8 (4.08%) of PDA assessments. They reported having drank no coffee in the last two hours on 176 (89.80%) of PDA assessments, a small amount of coffee on 17 (8.67%) of PDA assessments, and a large amount of coffee on 3 (1.53%) of PDA assessments.

Effect of AR on attentional bias. To restate, attentional bias index scores are calculated by subtracting the reaction times to identify probes that replace neutral stimuli from reaction times to identify probes that replace smoking stimuli. It is important to note that the AB data is only gathered from the daily presented standard VP task used to assess AB. Positive AB index scores reflect an AB toward smoking cues and negative AB index scores reflect an AB toward neutral cues (and away from smoking cues).

Table 6 reports the bias scores by group. Control participants tended to exhibit an attentional bias toward smoking cues. AR participants tended to exhibit an attentional bias away from smoking cues. Aggregated over observations the difference in bias scores was 38.4 ms. **Figure 7-A** illustrates the effect of group on AB aggregated over observations.

When aggregating over subjects, control participants tended to exhibit an attentional bias toward smoking cues ($n = 3$, $M = 18.0$ ms, $SD = 11.8$). AR participants tended to exhibit an attentional bias away from smoking cues ($n = 6$, $M = -24.8$ ms, $SD = 68.5$). Four of the 6 AR participants (66%) exhibited a negative bias score. None of the 3 control participants (0%) exhibited a negative bias score. The between-group effect size was $d = 0.87$.

Figure 7-B illustrates the effect of group over time. As can be seen, attentional bias appears to remain stable and positive for the control group, but there is a tendency for attentional bias to become more negative in the AR group.

Cue-Provoked Craving Measure. We assessed the performance of our novel cue-provoked craving measure by examining the difference in craving on the cue craving measure compared to the craving measure. Across all 9 participants, there was a mean increase of 0.16 ($SD = 0.44$) on the cue craving measure. This corresponds to the small to moderate effect size ($d = 0.36$). Theoretically, we would expect cue-provoked craving to be higher in the control group. In these participants ($n = 3$) there was a mean increase of 0.34 ($SD = 0.29$).

Effect of AR on craving. Cue-provoked craving index scores reported in **Figures 8-C** and **8-D** are calculated by subtracting the average craving reported on

the non-cue provoked craving item from the average craving reported on the cue-provoked craving item at each random assessment. In contrast to the AB index scores, the craving data are taken from each random assessment including AR or control tasks and the standard VP task. Higher values reflect greater cue-provoked craving than non-cue-provoked craving while lower values reflect lower cue-provoked craving. **Table 6** reports the craving scores by group. For the individual craving items, the Control participants reported lower craving ratings than the AR participants for both the craving item ($d = 0.62$) and the cue craving item ($d = 0.38$). For the cue-provoked craving score, over all observations control participants exhibited a score of 0.33 ($SD = 1.51$). AR participants exhibited a cue-provoked craving score of 0.08 ($SD = 1.28$). The difference in cue-provoked craving was 0.25. **Figure 7-C** illustrates cue-provoked craving scores aggregated over subjects. Control participants exhibited a cue-provoked score of 0.34 ($SD = 0.29$). AR participants exhibited a cue-provoked score of 0.07 ($SD = 0.50$). The between-group effect size was $d = 0.66$.

Figure 7-D illustrates the effect of group on cue-provoked craving over time. As can be seen, cue-provoked craving tended to increase for the control group, but there is a tendency for cue-provoked craving to decrease (become more negative) in the AR group.

Smoking Logs. Data on reported smoking on the day of the visit 2 session was not included in the analyses because these data did not reflect smoking for a whole day. Participants in the control group reported smoking an average of 7.5 cigarettes per day ($SD = 4.9$). Participants in the AR group reported smoking an

average of 10.8 cigarettes per day (SD = 5.5). As noted in Table 5, participants in the Control group reported smoking an average of 11.67 (SD = 1.53) cigarettes per day at baseline, whereas participants in the AR group reported smoking 15.83 cigarettes per day at baseline. Thus, the change (reduction) in reported smoking was 4.17 cigarettes per day (Control group) and 5.03 cigarettes per day (AR group).

When broken down by time, the Control group reported smoking an average of 8.3 cigarettes/day (SD = 4.40) on days 1-4 and 6.3 cigarettes/day (SD = 5.6) on days 5+. The AR group reported smoking an average of 11.5 cigarettes/day (SD = 5.9) on days 1-4 and 9.9 cigarettes/day (SD = 5.5) on days 5+.

Lab Data

Effect of AR on attentional bias. Each participant completed the VP task lab at visit 1 and lab visit 2. **Table 7** reports the bias scores by group. At visit 1 (pre-intervention), attentional bias was slightly lower in the AR group than the Control group ($d = 0.10$). Control participants tended to exhibit an increase in attentional bias from visit 1 to visit 2 ($n = 3$, Mean change = +11.3 ms, SD = 36.5). AR participants tended to exhibit a decrease in attentional bias from visit 1 to visit 2 ($n = 6$, Mean change = -15.7 ms, SD = 67.4). The difference in the change in bias scores was 27.0 ms. The between-group effect size was $d = 0.50$.

Effect of AR on craving. Each participant completed the two craving items on the PDA at visit 1 and lab visit 2. **Table 7** reports the craving scores by group. At visit 1 (pre-intervention), craving ratings were higher in the AR group than the control group for both the craving item ($d = 0.17$) and the cue craving item ($d = 0.87$). Control participants tended to exhibit a decrease in craving from visit 1 to visit 2 for

both items (craving: Mean change = -1.00, SD = 3.46; cue craving: Mean change = -1.00, SD = 1.73), as did AR participants (craving: Mean change = -0.50, SD = 2.43; cue craving: Mean change = -0.33, SD = 1.86). The between-group effect sizes for the change scores were $d = 0.17$ (craving) and $d = 0.37$ (cue craving).

QSU Ratings. **Table 7** reports the QSU ratings at visit 1 and visit 2. QSU ratings tended to decrease in the control group (Mean change = -0.37, SD = 1.06). QSU ratings tended to increase in the AR group (Mean change = +0.88, SD = 4.08). The between-group effect size (for change in QSU ratings) was $d = 0.42$.

Breath CO. **Table 7** reports the breath CO data at visit 1 and visit 2. CO levels tended to decrease in the control group (Mean change = -8.67, SD = 5.78), and in the AR group (Mean change = -2.17, SD = 5.60). The between-group effect size (for change in QSU ratings) was $d = 1.14$.

Salivary cotinine. **Table 7** reports the salivary cotinine data at visit 1 and visit 2. Cotinine levels tended to decrease in the control group (Mean change = -100.63, SD = 32.18), and in the AR group (Mean change = -96.56, SD = 186.38). The between-group effect size (for change in cotinine levels) was $d = 0.03$.

Mobile-Eye Assessment. The hardware and software used for mobile eye tracking data collection and analysis appeared to function as expected (see **Figure 8** for a screenshot of the software).

Table 8 reports the mobile eye data for the pilot participants ($n = 8$). One AR participant's mobile eye data was lost due to improper calibration of the spectacle mounted cameras. A smaller proportion of the AR group's fixations was on smoking stimuli ($d = 0.40$). The AR group spent less time on average looking at smoking

stimuli ($d = 0.54$), and the percentage of time looking at the smoking stimuli was lower in the AR group ($d = 0.54$).

Discussion and Implications

The primary aim of the pilot study was to examine the feasibility of administering AR on a PDA in an EMA study. The findings described below indicated feasibility.

First, the software adaptations for the VP task using the virtual landscape mode appeared to function appropriately on a consistent basis. However, there was one PDA error that caused loss of data. The cause of this error was determined to be an unknown software malfunction. It was not replicated in other PDAs and so was not systemic. It is possible that it was simply a transient aberration in loading the PDA software. All other PDAs operated as expected.

Second, we determined overall participant compliance. Compliance in EMA studies is critical (Stone & Shiffman, 2002). If participants fail to complete the random assessments on a consistent basis then the data are less likely to reflect representative samples of their daily lives. This problem is especially pertinent in the current study. To monitor attentional bias change over time it is necessary for participants to complete the one attentional bias assessment per day on most days. Moreover, while this is an assessment study, it is also an intervention (AR) study. This requires that the training tasks are completed on a large proportion of assessments in order that adequate training is administered. The study had an acceptable compliance rate of 77% and the CIs overlap with 80%. Stone and Shiffman (2002) have considered 80% to be an acceptable level of compliance. This

level is consistent with other EMA studies utilizing cognitive tasks (Waters and Li, 2008). It is possible that compliance declines over the course of the study. We will examine this possibility using data from a larger study.

Third, we wanted to assess participant burden. In laboratory studies AR can last longer than 60 minutes for a single session (MacLeod et al., 2002; Attwood et al., 2008). We needed to balance the need for AR to be of sufficient duration to effect change in AB with a desire to not overburden the participants. For this reason, we ensured the AR or control training tasks lasted around 7-9 minutes. Of course, AR and control training tasks were longer in duration than assessments (because they included more trials). Participants completed the AR and control training assessments in around ten minutes. This is consistent with our prediction and does not seem excessively burdensome.

Last, it is important that participants be able to complete assessments with minimal interruption. Participants need to be able to concentrate on the task at hand and, given that the differences in RT to probes between picture types is typically 25 ms or less using this task, one can see that interruptions (that would likely increase RTs) could easily add a lot of noise to the data. This challenge is true of all EMA studies, but is especially true in those EMA studies utilizing cognitive tasks based on RT. In this study, on the majority of assessments (69.4%) participants reported that they completed the VP task (or training) without being interrupted. This figure is comparable to that reported in Waters & Li (62.4%) (2008) and reflects an acceptable level of interruption. The effect of reported interruptions on performance of the VP task can be more formally assessed in the main study.

The secondary aim of the study was to present descriptive data from study measures from both field and laboratory. Although the sample sizes were very small, a few trends emerged. Of course, any trends noted should be treated with a high degree of caution given the small sample sizes and absence of inferential statistics. We focus our discussion on the effect of AR on the primary outcome measure, attentional bias.

First, the pattern of attentional bias data is consistent with expectations. Participants in the AR group exhibited a more negative attentional bias than those in the control group, and their attentional bias appeared to become more negative over time (**Figure 7**). Similarly, participants in the AR exhibited a more negative change in attentional bias from visit 1 to visit 2 assessed on the PDA. These between-group effects were in the moderate (lab) to large (field) ranges. Confidence in these initial findings is also bolstered by the fact that a similar pattern of data was observed in the field and lab settings.

The findings from the mobile eye tracking portion also appeared to conform to expectations. It appears that the control group spent more time looking at the smoking stimuli and had more total fixations on the smoking stimuli. It is possible that the AR had the effect of training participants to look away from smoking cues and attend more to neutral features in their environment. The addition of this novel measure of AB may be sensitive to training-induced changes in the attentional system. As stated previously, this pilot study is not large enough to allow us to draw strong inferences from these preliminary findings. However, this measure does appear to be promising.

If AR is truly altering the attentional bias we would expect to see these changes in other measures of attentional bias. Some previous studies have failed to demonstrate that the effect of AR generalizes to other measures of AB (e.g., Schoenmakers et al., 2007). Given this finding, it is important that we assess the generalization of attentional bias to other measures of this construct, such as eye tracking. Also, we hypothesize that attentional in the natural environment will be altered as a result of AR delivered in an EMA setting. Therefore, it is important to include an ecologically valid measure of attentional bias.

In contrast to the seemingly consistent results for attentional bias, the pattern of results for the craving data was more mixed. For example, participants in the AR group tended to report higher (not lower) craving ratings (both items) in the field than those in the control group. However, interpretation of these data is not straightforward because AR participants also tended to report higher craving ratings (both items, and QSU ratings) at visit 1 (pre-intervention). AR participants tended to exhibit smaller changes (decreases) in craving ratings from visit 1 to visit 2. Again, this trend is contrary to hypotheses. On the other hand, AR participants tended to exhibit smaller cue-provoked craving scores than control participants (**Figure 7**) and this between-group difference tended to get larger over time. In fact, the decrease in cue-provoked craving in the AR group resembled the decrease in attentional bias over time. It is possible that, as AR participants are trained to attend away from smoking cues, they experience a smaller increase in craving from the smoking cues because they are less likely to attend to the smoking cue. (They may be attending to a neutral part of the pictures).

Interestingly, both the AR participants and Control participants tended to reduce their smoke intake during the week. The pattern of data indicating decreased smoking over time was evident for both CO levels and cotinine levels (as well as reported smoking in the smoking logs). For example, the cotinine levels of both groups decreased by around 100 ng/ml from visit 1 to visit 2¹.

Limitations of Study

The study had a number of limitations. The main limitation of this feasibility study was the small sample size. This precluded a detailed examination of the effect of AR on the outcome measures. Another limitation of the study is that the reliability and validity of visual probe task assessed during EMA is not known.

Strengths of Study

Despite these limitations the pilot study had a number of strengths. It is the first study to assess the feasibility of using PDAs to administer a cognitive retraining intervention. In doing so, we administered a larger number of doses of AR than any other study. If future research confirmed that it is possible to administer cognitive interventions on a PDA this methodology would be highly significant in that it could be applied to other addictions, unhealthy behaviors, or psychopathologies. For example, cognitive training for executive function (e.g., McNab et al., 2009) might be usefully administered on PDAs. Another strength of the study is that it is also the first study to assess the utility of using a mobile eye-tracker to assess attentional processes in a naturalistic setting.

Conclusions

In summary, this study has shown that it is feasible to administer a cognitive retraining intervention on a PDA in an EMA study. In addition, the preliminary data from this small pilot study seem to resemble the extant literature on attentional retraining and smoking. The effect of AR on attentional bias appears to be consistent with expectations, but the effect of AR on craving and use seems more complex. Future research with a larger sample size is required and currently underway to provide much richer data that will clarify these issues.

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Footnotes

¹The change in cotinine levels, while apparently dramatic, does not reach statistical significance ($p > .05$).

Table 1: Summary table of existing Attention Retraining literature in the addictions.

Study	AR Sessions	AR trials (Assessment trials)	Participants	AR Groups	Main Outcome Variables	Main Findings
Field et al., 2009	1 session (24h later assessment session)	Visual Probe: 1,792 (320) Pictorial Stroop: NA (160)	72 Current smokers	Attend-Smoking vs. Avoid-Smoking	Attentional Bias (VP and Stroop); QSU – Brief, Tobacco Seeking (willingness to pay delay discounting)	Attentional Bias (VP): Group by Time interaction at second session for trained but not novel stimuli. Attentional Bias (Pict. Stroop): No Effect Craving (QSU): Main effect of time. Tobacco Seeking : No Effect
Fadardi and Cox, 2009 Sample 2	2 sessions, 1 week apart	Pictorial Stroop: Not reported Emotional/ Classic Stroop: (384)	68 Hazardous drinkers	Avoid-Alcohol	Attentional Bias (Alcohol, Concern, Classic Stroop task); Motivation to Change (RTCQ)	Attentional Bias : Stroop by Time interaction. Craving : Not Assessed Motivation to Change : Heaviest drinkers showed increased motivation to change their drinking behavior
Fadardi and Cox, 2009 Sample 3	4 sessions, 1 per week for 2 4 weeks	Pictorial Stroop: Not reported Emotional / Classic Stroop: (768)	92 Harmful drinkers	Avoid-Alcohol	Attentional Bias (Alcohol, Concern, Classic Stroop task); Motivation to Change (RTCQ), Alcohol Consumption (TAAD)	Attentional Bias : Stroop by Time interaction. Craving : Not Assessed Motivation to Change : Main effect of Time. Alcohol Consumption : Main effect of Time - decrease in consumption at post-training.
Attwood et al., 2008	Single Session	512 (256)	55 Current smokers	Attend-Smoking vs. Avoid-Smoking	Attentional Bias (VP); QSU – Brief, VAS; Smoking topography	Attentional Bias (VP): Group by Time interaction. Craving (QSU): Group by Time interaction for males but not for females. In males: change in AB across training correlated with change in craving across cue exposure. Smoking Topography : No effect
Field et al., 2007	Single Session	960 (1,724)	60 Heavy social drinkers	Attend-Alcohol vs. Avoid-Alcohol vs. Control	Attentional Bias (VP + Alcohol Stroop); SRC Task; Urge to drink, DAQ; Alcohol consumption (Alcohol vs. Orange Juice)	Attentional Bias (VP): Group by Time interaction. Alcohol Stroop: no effect Craving (Urge to drink): Time Alcohol Consumption : No effect
Schoenmakers et al., 2007	Single Session	624 (100)	106 Heavy drinkers	Avoid-Alcohol vs. Control	Attentional Bias (VP); Craving; Drink choice task (soda vs. beer)	Attentional Bias (VP): Group by Time interaction. Craving : No effect Drink Choice : No effect
Field and Eastwood, 2005	Single Session	896 (126)	40 Social drinkers	Attend-Alcohol vs. Avoid-Alcohol	Attentional Bias (VP); DAQ, ACS, Urge to drink, alcohol; Alcohol consumption (Beer vs. Orange)	Attentional Bias (VP): Group by Time interaction; attend-alcohol group significant increase over time, avoid-alcohol group significant decrease over time. Craving (Urge to drink): Group by Time interaction, attend-alcohol group increased over time. Alcohol Consumption : attend-alcohol group consumed significantly more beer.

Table 1 Note: AB = Attentional Bias; AR = Attentional Retraining; DAQ = Desire for Alcohol Questionnaire; QSU = Questionnaire for Smoking Urges; SRC = Stimulus-response Compatibility task; VAS = Visual Analog Scale; VP = Visual Probe Task. In the single session studies, the outcome variables were assessed before and after AR.

Table 2: Summary of Study Procedures.

	Phone Scr.	Visit 1 (Day 0)	Day +1	Day +2	Day +3	Day +4	Day +5	Day +6	Visit 2 (Day +7)
Modality/Location of Contact	Phone	USUHS							USUHS
Inclusion/Exclusion Criteria	X	X							
QUESTIONNAIRE ASSESSMENTS									
Demographics		X							
Smoking History		X							
FTND		X							
BIDR		X							
QSU		X							X
Smoking Assessments (Diary)		X	X	X	X	X	X	X	X
BIOCHEMICAL ASSESSMENT									
Breath Sample for CO		X							X
Saliva Sample for Cotinine		X							X
INFORMED CONSENT									
Participant signs ICD		X							
RANDOMIZATION									
Assignment to AR or Control		X							
PDA TRAINING									
Participant receives training		X							
LAB ASSESSMENTS									
Standard VP Task		X							X
Mobile Eye Assessment									X
PDA ASSESSMENTS									
4 RAs per day		X	X	X	X	X	X	X	X
COMPENSATION*									
Laboratory Sessions		\$20							\$20
Days contributing data		\$5	\$5	\$5	\$5	\$5	\$5	\$5	
Each PDA assessment		\$2	\$2	\$2	\$2	\$2	\$2	\$2	\$2
ESTIMATED DURATION									
Minutes**	10	90 (lab) + 30 (RAs)	40	40	40	40	40	40	60 (lab) + 10 (RA)

Table 2 Note: FTND = Fagerstrom Test for Nicotine Dependence; QSU = Questionnaire for Smoking Urges; BIDR = Balanced Inventory of Desirable Responding; CO = carbon monoxide; VP = visual probe task; RA = Random Assessments. *Non-federal civilians (see text for compensation procedures for federal civilians); **Assumes 1) completion of 4 PDA assessments per day for days 1-6; 2) participants will complete 3 PDA assessments on the day of the orientation visit (visit 1) and 1 PDA assessment on day of the second visit; 3) mean RA duration = 10 minutes; 4) Duration of laboratory visit 1 = 90 minutes; and 5) Duration of laboratory visit 2 = 60 minutes

Table 3: Summary of assessments for AR group and Control groups.

Visit 1	Group	Day 0	Day +1	Day +2	Day +3	Day +4	Day +5	Day +6	Day +7	Visit 2
(Day 0)										(Day +7)
VP-Lab	AR		AR1	AR1	AR1	AR1	AR1	AR1	AR1	VP-Lab
		AR2	AR2	AR2	AR2	AR2	AR2	AR2		
		AR3	AR3	AR3	AR3	AR3	AR3	AR3		
		VP-PDA	VP-PDA	VP-PDA	VP-PDA	VP-PDA	VP-PDA	VP-PDA		
VP-Lab	CON		C1	C1	C1	C1	C1	C1	C1	VP-Lab
		C2	C2	C2	C2	C2	C2	C2		
		C3	C3	C3	C3	C3	C3	C3		
		VP-PDA	VP-PDA	VP-PDA	VP-PDA	VP-PDA	VP-PDA	VP-PDA		

Table 3 Note: AR = Attentional Retraining group; CON = Control group; VP-Lab = Visual Probe task assessed in the laboratory; VP-PDA = visual probe task assessed on PDA; AR1 = first AR task of day; AR2 = second AR task of day; AR3 = third AR task of day; C1 = first control task of day; C2 = second control task of day; C3 = third control task of day. The table assumes that the participants will complete two AR assessments on the day of the orientation visit (visit 1) and one AR assessment on the day of the second visit. (This may vary across participants).

Table 4: Sample of the sets of stimuli used for eight participants over the course of the eight days of the AR.

	Day 0	Day +1	Day +2	Day +3	Day +4	Day +5	Day +6	Day +7
Participant 1	C	E	G	D	B	H	A	F
Participant 2	A	C	D	G	F	F	C	B
Participant 3	B	F	E	A	G	H	C	D
Participant 4	D	F	G	B	C	A	F	E
Participant 5	A	G	B	C	D	F	G	E
Participant 6	B	G	C	D	A	E	G	F
Participant 7	C	A	G	F	G	B	E	D
Participant 8	D	C	F	E	A	H	B	G

Table 4 Note: Stimuli sets A – H are randomly ordered over the course of the eight days.

Table 5: Demographic characteristics of Pilot Sample

	Control (n = 3)	AR (n = 6)
<i>Participant Demographics</i>		
Sex	1 F 2M	3F 3M
Age	53.33 (5.13)	50.50 (4.59)
Years of Education	13.67 (2.08)	12.50 (1.38)
Cigarettes per day	11.67 (1.53)	15.83 (6.65)
FTND (0-10)	4.00 (1.73)	3.50 (1.52)
Age when started daily smoking	15.33 (0.58)	21.17 (11.23)
Lifetime Quit Attempts (+24hrs)	7.33 (2.89)	6.17 (3.49)

Table 5 Note: Mean (SD) for Participant Demographics. FTND: Fagerstrom Test of Nicotine Dependence.

Table 6: Pilot Results from EMA portion of study.

	Control Training (n = 58)	Assessment (n = 18)	AR Training (n = 93)	Assessment (n = 27)	All (N = 196) ¹
<i>EMA data</i>					
<i>Attentional Bias</i>					
Bias Score (ms)		17.3 (40.9)		-17.5 (96.4)	-3.5 (80.2)
<i>Craving</i>					
Craving (1-7)	3.00 (1.40)	2.78 (1.56)	3.52 (1.70)	3.78 (2.19)	3.33 (1.70)
Cue Craving (1-7)	3.34 (1.65)	3.06 (1.59)	3.58 (1.77)	3.93 (2.20)	3.51 (1.78)
Cue-Provoked Craving (-6 to +6)	0.34 (1.66)	0.27 (0.89)	0.06 (1.32)	0.15 (1.17)	0.18 (1.38)
<i>Subjective variables</i>					
Negative Affect (1-7) ^a	2.45 (0.98)	2.44 (0.90)	2.87 (0.83)	2.82 (0.98)	2.70 (0.92)
State Anxiety (1-7) ^a	2.36 (1.03)	2.28 (0.97)	2.65 (0.91)	2.65 (1.03)	2.53 (0.97)
Mood (1-7)	5.31 (1.30)	5.00 (1.46)	4.82 (1.22)	4.74 (1.43)	4.97 (1.30)
Energy-level (1-7)	5.64 (1.00)	5.50 (1.04)	4.54 (1.09)	4.30 (1.73)	4.92 (1.29)
Difficulty Concentrating (1-7)	2.24 (1.66)	2.17 (1.65)	2.62 (1.48)	2.59 (1.53)	2.46 (1.56)
Hunger (1-7)	3.03 (1.49)	2.89 (1.52)	3.24 (1.97)	3.13 (2.02)	3.04 (1.84)

Table 6 Note. Mean (SD) for Bias scores, Craving, and other Subjective measures; ¹ N for bias scores = 45

^aState Anxiety is mean of 6-items, and Negative Affect is mean of 7-items (see text).

Table 7: Pilot Results from Lab portion of study.

	Control		AR	
	Visit 1 (n = 3)	Visit 2 (n = 3)	Visit 1 (n = 6)	Visit 2 (n = 6)
<i>Lab Data</i>				
<i>Attentional Bias</i>				
Bias Score (ms)	-3.8 (27.8)	7.5 (12.0)	-6.8 (34.1)	-22.4 (53.4)
<i>Craving</i>				
Craving (1-7)	3.67 (2.52)	2.67 (1.53)	4.00 (1.26)	3.50 (1.64)
Cue Craving (1-7)	3.33 (1.15)	2.33 (1.53)	4.17 (0.75)	3.83 (2.04)
Cue-Provoked Craving (-7 to +7)	-0.33 (1.53)	-0.33 (1.53)	0.17 (0.98)	0.33 (1.37)
<i>Subjective variables</i>				
Negative Affect (1-7) ^a	2.43 (1.51)	2.48 (1.01)	2.95 (1.21)	2.29 (0.88)
State Anxiety (1-7) ^a	2.17 (1.59)	2.89 (1.35)	2.00 (0.28)	2.53 (1.13)
Mood (1-7)	6.00 (1.73)	5.67 (0.58)	5.67 (0.82)	5.17 (0.98)
Energy-level (1-7)	5.67 (1.53)	6.33 (0.58)	5.17 (0.98)	5.17 (0.98)
Difficulty Concentrating (1-7)	2.00 (1.73)	2.67 (2.08)	2.00 (0.63)	1.67 (1.21)
Hunger (1-7)	3.67 (2.52)	3.00 (1.00)	4.50 (1.64)	4.67 (1.97)
QSU Ratings (0-10)	3.83 (1.94)	3.47 (2.37)	4.93 (2.01)	5.82 (2.45)
<i>Physiological variables</i>				
Breath CO (ppm)	18.00 (8.00)	9.33 (4.16)	15.00 (7.93)	12.83 (5.38)
Salivary Cotinine (ng/ml)	392.92 (239.57)	292.29 (236.38)	327.36 (194.15)	230.80 (208.80)

Table 7 Note. Mean (SD) for Bias scores, Craving, other Subjective measures, and Physiological measures for lab portion of study. QSU = Questionnaire of Smoking Urges, CO = Carbon Monoxide.

^aState Anxiety is mean of 6-items, and Negative Affect is mean of 7-items (see text).

Table 8: Gaze and fixation data from pilot study.

	Control (N=3)	AR (N=5)
<i>Mobile Eye Data</i>		
Total Number of Fixations	5.33 (0.58)	4.00 (2.12)
Fixations on Smoking Stimuli	2.00 (2.65)	1.20 (2.17)
Percentage of Fixations on Smoking Stimuli	34.44% (43.50)	19.29% (31.09)
Total Fixation duration on Smoking Stimuli (seconds)*	0.92 (0.97)	0.85 (0.87)
Number of fixations before first fixation on smoking stimuli*	2.00 (1.41)	1.50 (2.12)
Duration before first fixation on smoking stimuli (seconds)*	3.96 (0.49)	2.69 (2.95)
Total time looking at smoking stimuli (seconds)	.90 (1.08)	0.40 (0.76)
Percentage of time spent looking at smoking stimuli	17.95% (21.54)	7.91% (15.14)

Table 8 Note: Mean (SD) of selected mobile eye tracking data from pilot participants.

*Of those that who had fixations on smoking stimuli (Control = 2, AR = 2)

Figure 1: Visual Angles on Portrait and Landscape PDA Orientations.

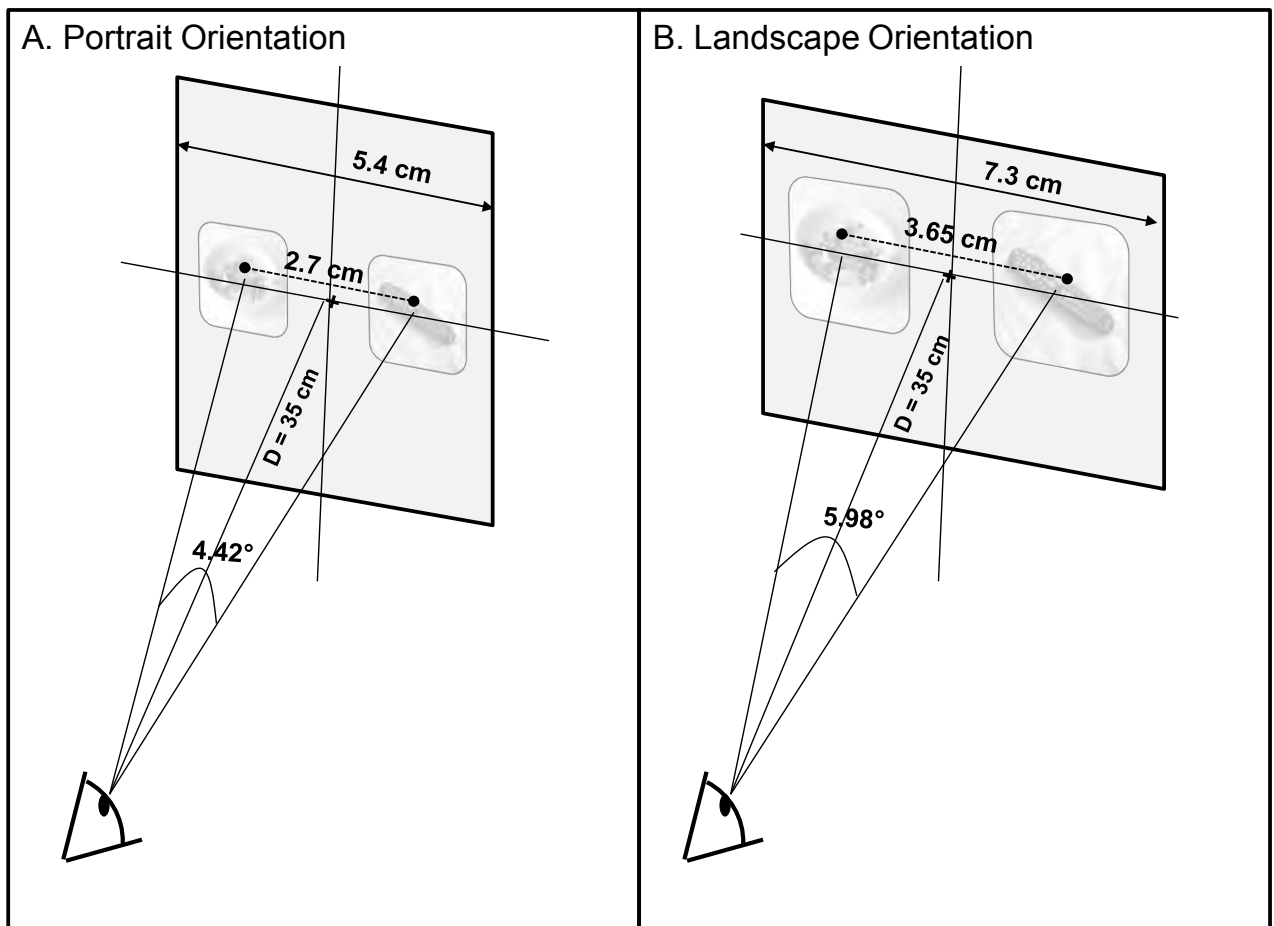


Figure 1 Note: Visual angles from center of stimuli calculated assuming PDAs are held at 35 centimeters from participants' faces. Screen, images, and lines are not drawn to scale. cm = centimeters, D = Distance.

Figure 2: Screenshots of a participant completing the visual probe task.

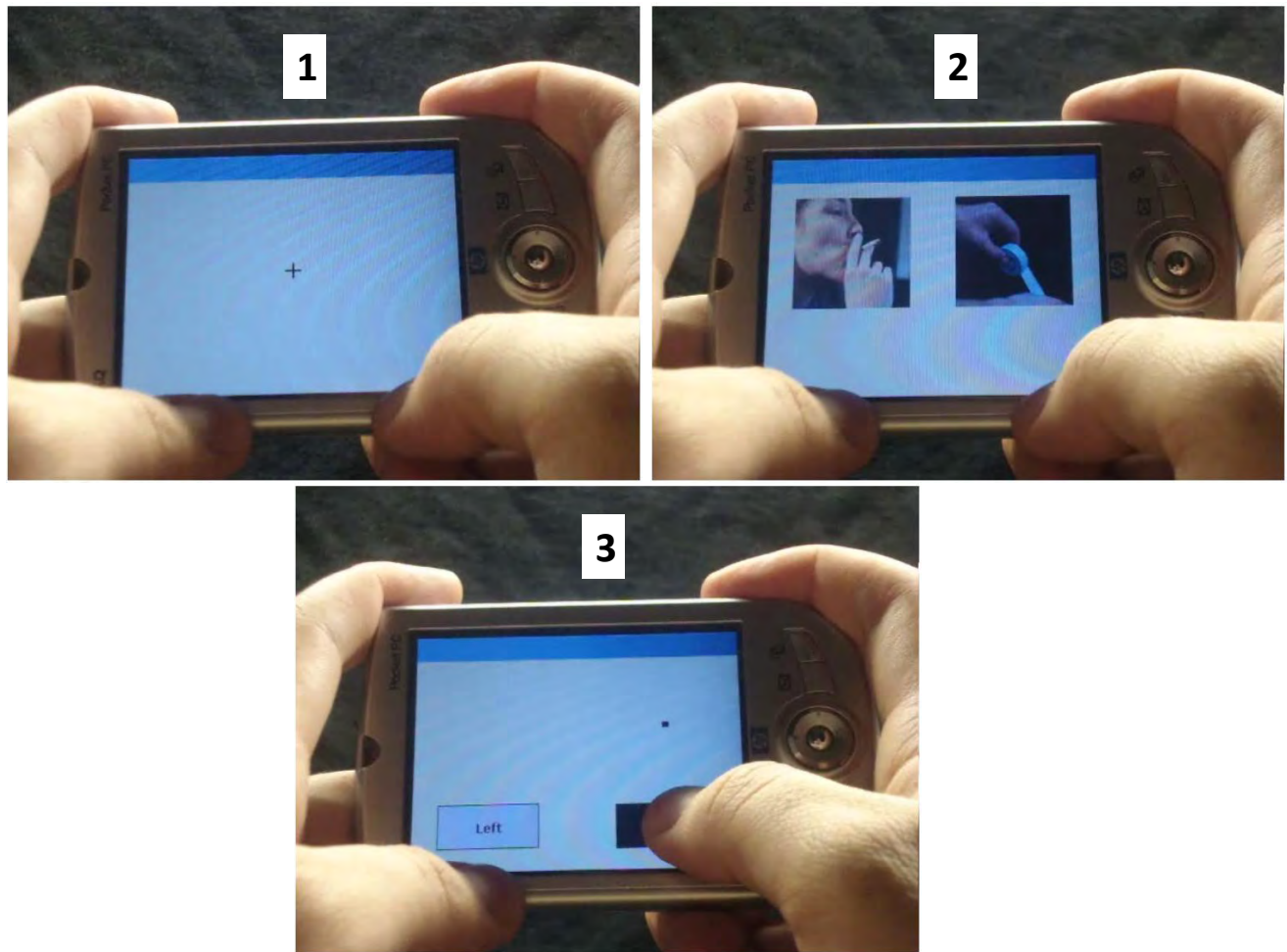


Figure 2 Note: Diagram of sequence of events in a single VP trial. 1) The fixation cross is presented for 500ms, 2) the two pictures – one smoking and one neutral- are displayed (500 ms), and 3) the probe to which the participant must respond is presented.

Figure 3: Timeline with major study milestones.

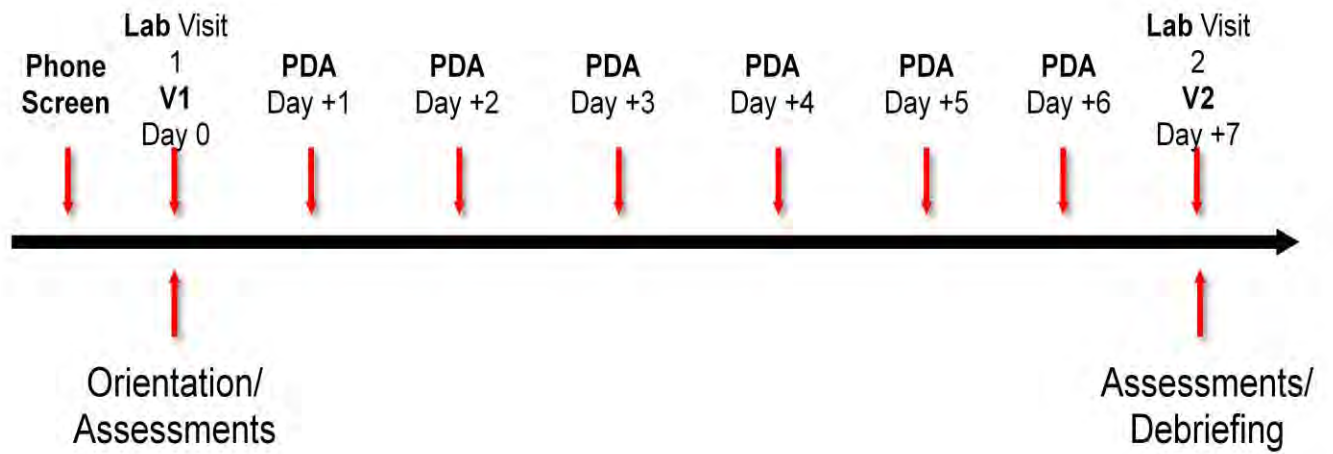
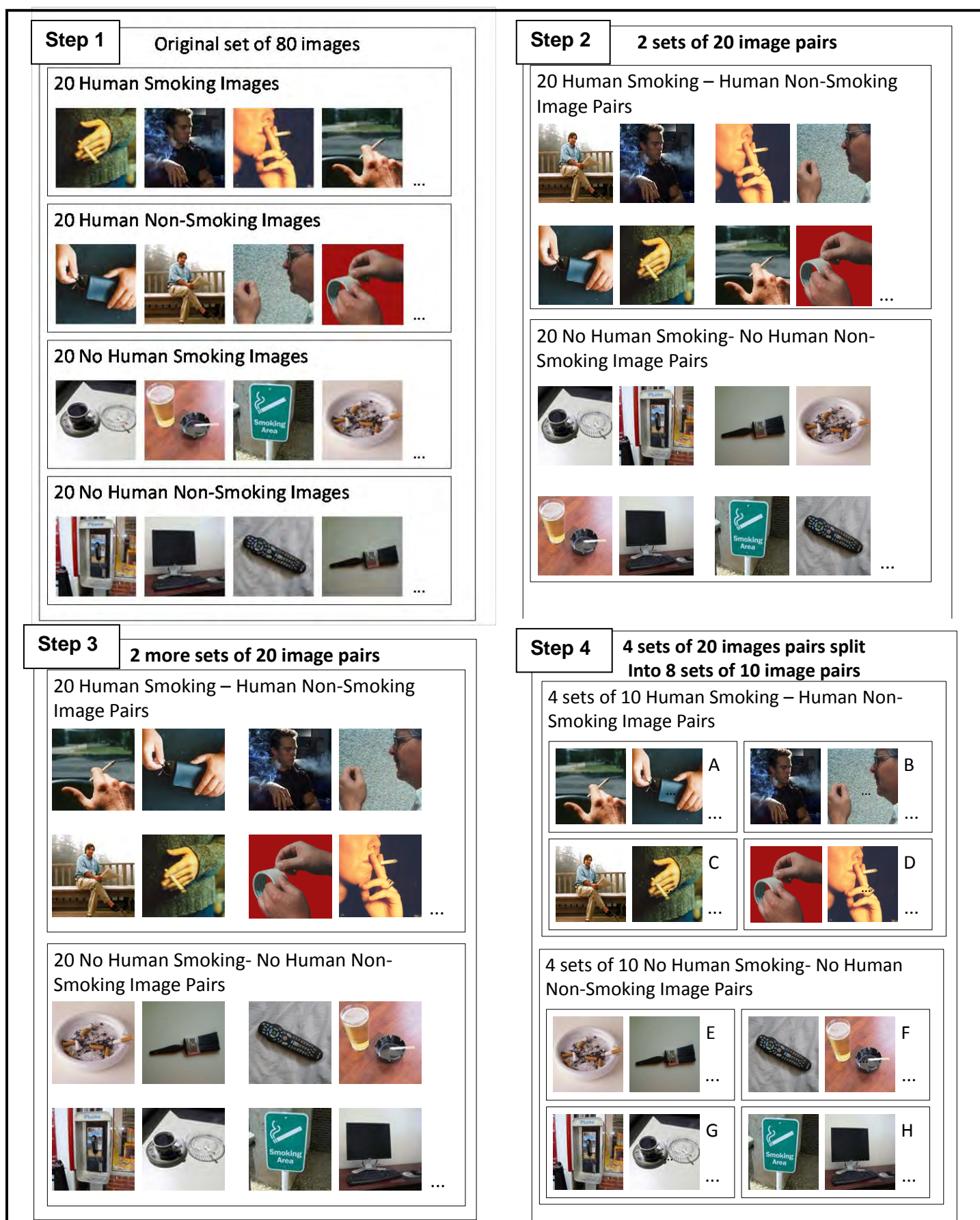


Figure 4: Sample smoking stimulus used for cue-provoked items.



Figure 5: Diagrammatic representation of the process used to arrive at 8 sets of 10 image pairs for use on the 8 days of participant training.



images within the groups human and nonhuman for 2 sets of 20 image pairs. Step 3: The same 80 images are randomly paired in different pairs again for another 2 sets of 20 image pairs (same images, novel pairing). Step 4: The existing 4 sets of 20 image pairs are each split in half for 8 sets of 10 image pairs. These 8 sets are labeled A through H.

Figure 6: Video frames and example summary data from the mobile-eye task for one example participant with Area of Interest (AOI), time stamp, and gaze fixations evident.

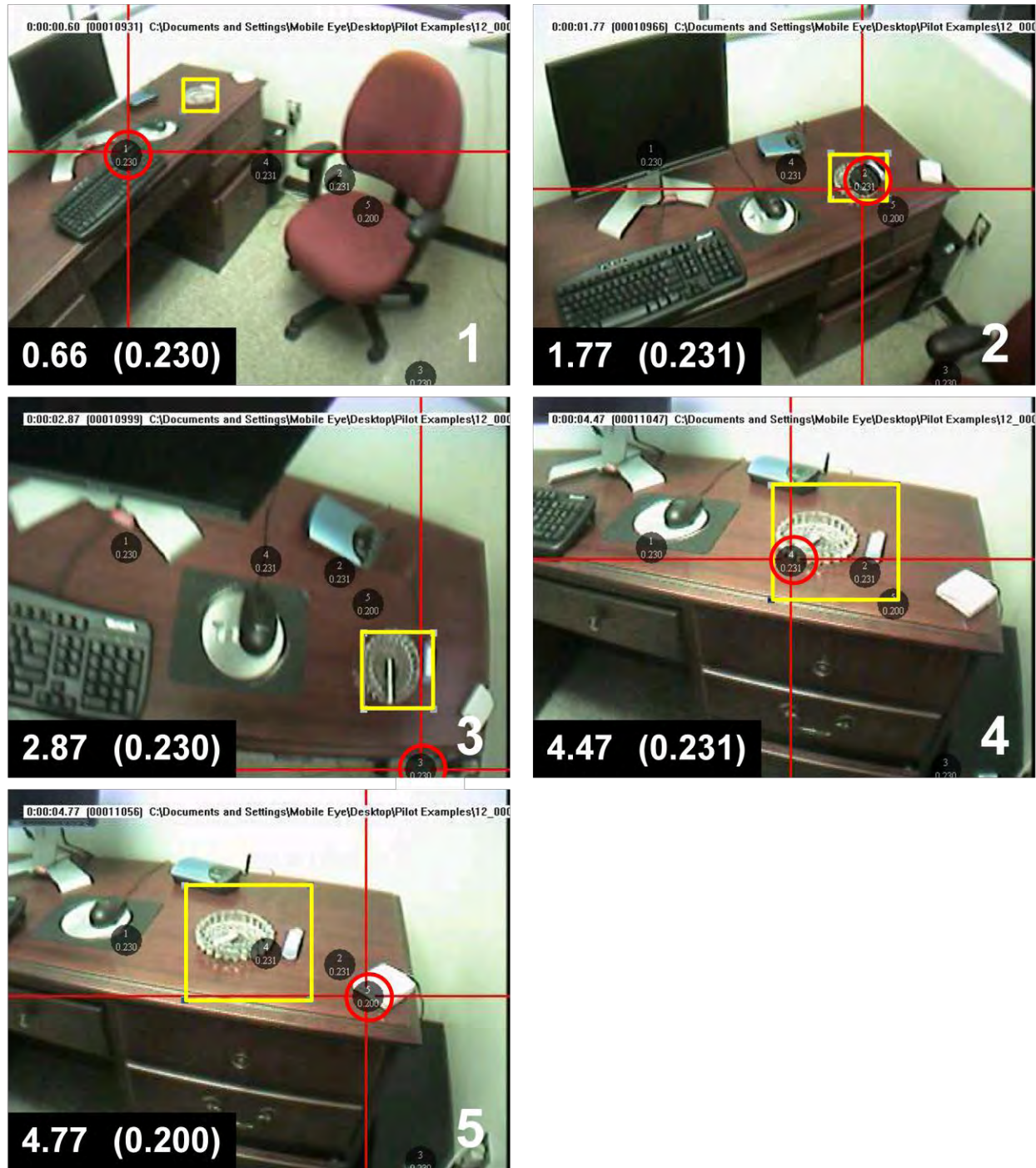


Figure 6 Note A: Screenshot of five video frames over 5.00 seconds duration of mobile eye task for one participant. Gaze tracking indicated by red circle and crosshairs. Area of Interest (AOI; smoking stimuli) highlighted in yellow. Elapsed time out of 5.00 seconds presented in lower left-hand corner of each frame along with fixation duration (in parentheses) in seconds. Each frame reflects one fixation in order of occurrence. This participant had five fixations. One fixation occurred before fixating on the smoking stimuli (fixation 1). Two fixations were on the smoking stimuli (fixations 2 and 4). And three fixations were not on smoking stimuli (fixations 1, 3, and 5). Time not accounted for within fixations were either saccades, loss of pupil data required for eye

tracking, or brief fixations lasting less than .200 seconds. Some of this additional time was spent looking at the smoking stimuli.

	Example Participant
<i>Mobile Eye Data</i>	
Total Number of Fixations	5.00
Fixations on Smoking Stimuli	2.00
Percentage of Fixations on Smoking Stimuli	40.00%
Total Fixation duration on Smoking Stimuli (seconds)	0.46
Number of fixations before first fixation on smoking stimuli	1.00
Duration before first fixation arrival (seconds)	1.76
Total time looking at smoking stimuli (seconds)	0.67
Percentage of time spent looking at smoking stimuli	13.40%

Figure 6 Note B: Mobile eye tracking data from example participant.

Figure 7: Attentional Bias and Craving data from nine pilot participants.

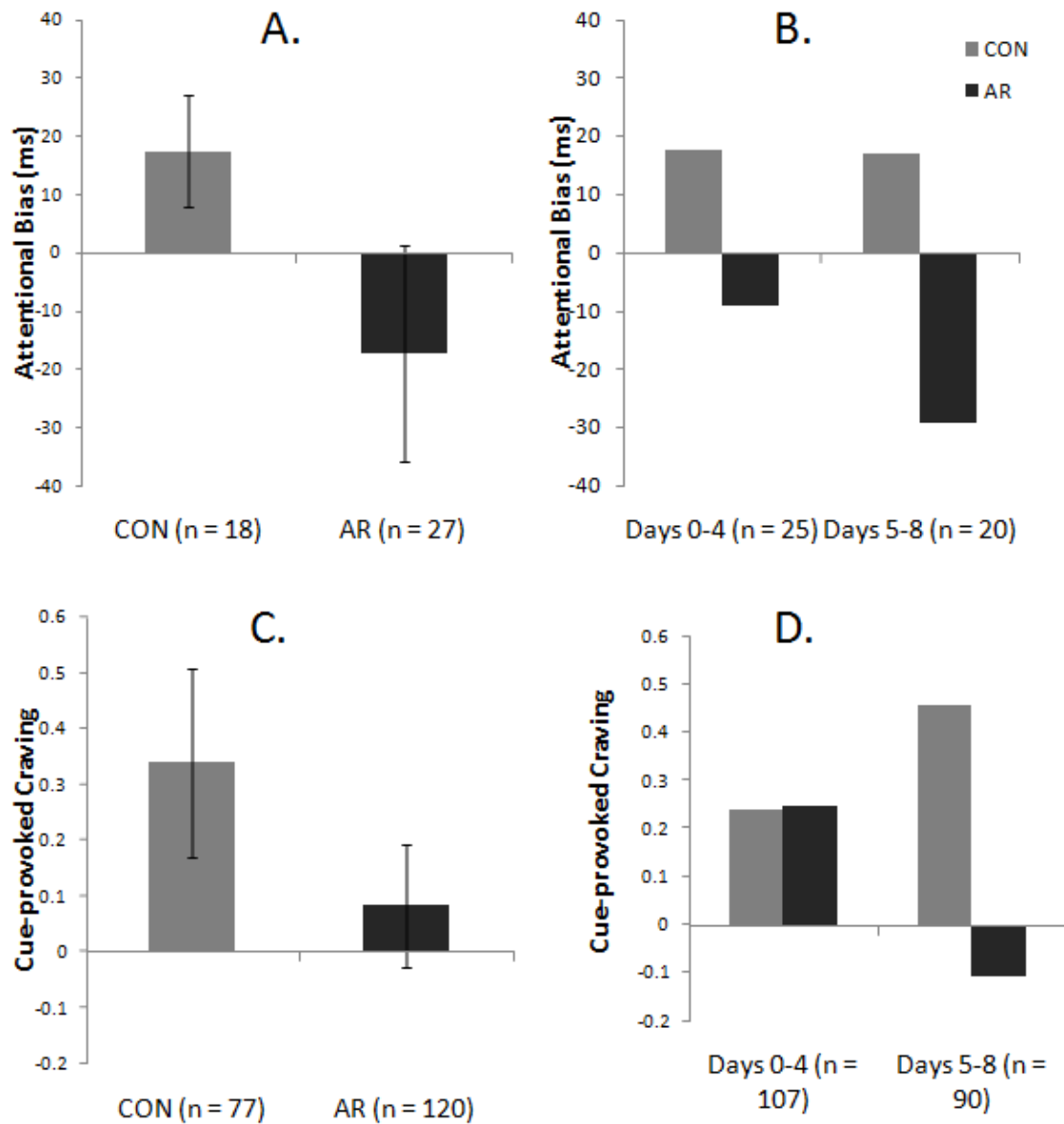


Figure 7 Note: (A). Mean Attentional Bias Index scores (1 SE) across all PDA assessments for 3 Control Participants (n = 18) and 6 AR Participants (n = 27) (B). Mean Attentional Bias Index scores across all PDA assessments (N=45) for 3 Control Participants and 6 AR Participants across Days 0-4 and Days 5-8 (C). Mean difference scores (1 SE) between cue-provoked craving scores and typical craving scores across all PDA random assessments for 3 Control Participants (n = 77) and 6 AR Participants (n = 120) (D). Mean differences between cue-provoked craving scores and typical craving scores across all PDA random assessments (N=197) for 3 Control Participants and 6 AR Participants across Days 0-4 and Days 5-8

Figure 8: Screenshot of Mobile Eye tracking software as participant enters naturalistic environment while looking at smoking stimulus.



Appendix A: Laboratory Self Report Measures

DEMOGRAPHICS QUESTIONNAIRE

Q1. What is your date of birth?

____ / ____ / ____
Refuse to Answer

Q2. What is your gender?

- | | |
|---|--------|
| 1 | Male |
| 2 | Female |

Q3. What is your present marital status? (Choose one)

- | | |
|---|-------------------------------|
| 1 | Single |
| 2 | Married |
| 3 | Divorced |
| 4 | Widowed |
| 5 | Living with significant other |
| 6 | Separated |
| 8 | Refuse to Answer |

Q4. How many years of education have you completed? (Choose one)

- | | |
|----|---|
| 01 | 1 (Elementary School) |
| 02 | 2 (Elementary School) |
| 03 | 3 (Elementary School) |
| 04 | 4 (Elementary School) |
| 05 | 5 (Elementary School) |
| 06 | 6 (Middle School) |
| 07 | 7 (Middle School) |
| 08 | 8 (Middle School) |
| 09 | 9 (High School) |
| 10 | 10 (High School) |
| 11 | 11 (High School) |
| 12 | 12 (High School) |
| 13 | 13 (Some College) |
| 14 | 14 (Vocational or Community College Degree) |
| 16 | 16 (Four Year College Degree) |
| 17 | 17 (Some Postgraduate Work) |
| 18 | 18 (Postgraduate Degree; Master Degree) |
| 20 | 20 (Postgraduate Degree; M.D., Ph.D., DDS, Dr.P.H., etc.) |
| 98 | Refuse to Answer |

Q5. Are you of Hispanic/Latino origin?

- | | |
|---|------------------|
| 1 | Yes |
| 0 | No |
| 8 | Refuse to Answer |

Q6. What category best describes your race? (Choose one)

- | | |
|---|--|
| 1 | Anglo American/Euro American/White |
| 2 | African American/Black |
| 3 | Asian American |
| 4 | Native of Hawaii or other Pacific Islander |
| 5 | Native American or Alaska Native |
| 6 | Mixed Race |
| 7 | Other |
| 8 | Refuse to Answer |

If Q6 is equal to 8 or Q6 is less than 7, then skip to Q8.

Q7. Please specify your race _____

Q8. Do you receive Medicare, Medicaid, or Medical Assistance currently?

- 1 Yes
- 0 No
- 7 Don't Know
- 8 Refuse to Answer

Q9. Do you have private insurance or group insurance?

- 1 Yes
- 0 No
- 7 Don't Know
- 8 Refuse to Answer

Q10. What is your total family income per year, before taxes? (Choose one)

- 01 Less than \$10,000 per year or less than about \$833 per month
- 02 \$10,000 to \$19,999 per year or less than about \$1250 per month
- 03 \$20,000 to \$29,999 per year or less than about \$2083 per month
- 04 \$30,000 to \$39,999 per year or less than about \$2916 per month
- 05 \$40,000 to \$49,999 per year or less than about \$3750 per month
- 06 \$50,000 to \$59,999 per year or less than about \$4583 per month
- 07 \$60,000 to \$69,999 per year or less than about \$5416 per month
- 08 \$70,000 to \$79,999 per year or less than about \$6250 per month
- 09 \$80,000 to \$89,999 per year or less than about \$7083 per month
- 10 \$90,000 to \$99,999 per year or less than about \$7916 per month
- 11 \$100,000 or more per year or more than \$8333 per month
- 98 Refuse to Answer

Q11. Generations in the U.S. Please choose the best response: (Choose one)

- 1 I'm an immigrant of the US
- 2 I was born in the US
- 3 One of my parents and I were born in the US (the other parent immigrated)
- 4 My parents and I were born in the US
- 5 My grandparents, my parents, and I were born in the US
- 6 My great-grandparents and ancestors were born in the US
- 8 Refuse to Answer

If Q11 is greater than 1, then skip to Q13.

Q12. What year did you immigrate to the US?

Refuse to Answer

Q13. Employment Status. Please choose the best response: (Choose one)

- 01 Regular full-time (30 or more hours per week)
- 02 Regular part-time (less than 30 hours per week)
- 03 Unemployed, currently *looking* for work
- 04 Unemployed, currently *NOT looking* for work
- 05 Homemaker
- 06 Student
- 07 Retired
- 08 Unable to work or disabled
- 09 Other
- 98 Refuse to Answer

If Q13 is less than 9, then skip to Q15.

Q14. Please specify your employment status.

Q15. In the past 30 days, what was the primary source of your income? (Choose one)

- 1 A job
- 2 Unemployment Benefits
- 3 VA/Disability/Social Security Income
- 4 Welfare/Food Stamps/Aid to Family with Dependent Children
- 5 Alimony or Child Support
- 6 Spouse/partner is main source of income
- 8 Refuse to Answer

SMOKING HISTORY QUESTIONNAIRE

About how old were you when you first started smoking at least 1 cigarette a day? _____ years old

About how old were you when you started smoking regularly **everyday**? _____ cigarettes a day

How many cigarettes do you smoke on a **normal day**? _____ cigarettes a day

	Definitely not	Probably not	Possibly	Probably	Definitely
Do you think you are addicted to smoking?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Are you seriously thinking of quitting smoking?

☐ ☐ Yes, within the next 30 days

☐ ☐ Yes, within the next 6 months

☐ ☐ No, not thinking of quitting

	Yes	No
Have you used any other tobacco products (i.e., cigars, pipes, smokeless tobacco, bidis, cloves)?	<input type="checkbox"/>	<input type="checkbox"/>

Describe:

	Yes	No
Have you ever made a serious and deliberate attempt to STOP SMOKING cigarettes completely?	<input type="checkbox"/>	<input type="checkbox"/>

If so, how many times?

_____ times

In the **last year**, how many times have you quit smoking for at least 24 hours?

_____ times

How hard was it for you to quit smoking on your most recent attempt?

Easy Slightly
Difficult Difficult Very
Difficult

How severely did you experience any of the following symptoms below in your most recent attempt to quit smoking? Choose the answer that most reflects the severity of each symptom.

	Not at all	Mild	Moderate	Severe	Very severe
Cravings for cigarettes	1	2	3	4	5
Irritability	1	2	3	4	5
Nervousness	1	2	3	4	5
Difficulty concentrating	1	2	3	4	5
Physical symptoms	1	2	3	4	5
Difficulty sleeping	1	2	3	4	5

FTND

	Within 5 minutes	6 to 30 minutes	31 to 60 minutes	After 60 minutes
How soon after you wake up do you smoke your <u>first</u> cigarette?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Do you find it difficult to refrain from smoking in places where it is forbidden, e.g., in church, at the library, in the cinema, etc.?			Yes <input type="checkbox"/>	No <input type="checkbox"/>
Which cigarette would you hate to give up most?			The first cigarette in the morning <input type="checkbox"/>	Any cigarette other than the first one <input type="checkbox"/>
How many cigarettes per day do you smoke?	10 or less <input type="checkbox"/>	11-20 <input type="checkbox"/>	21-30 <input type="checkbox"/>	31 or more <input type="checkbox"/>
Do you smoke more frequently during the first hours after waking than the rest of the day?			Yes <input type="checkbox"/>	No <input type="checkbox"/>
Do you smoke if you are so ill that you are in bed most of the day?			Yes <input type="checkbox"/>	No <input type="checkbox"/>

QUESTIONNAIRE FOR SMOKING URGES

Instructions: Indicate how much you agree or disagree with each of the following statements by circling the number between strongly disagree and strongly agree. The closer you choose a number to one end or the other indicates the strength of your disagreement or agreement. Please complete every item. We are interested in how you are thinking or feeling right now as you are filling out the questionnaire.

	Strongly Disagree					Strongly Agree
1. I have a desire for a cigarette.	0	1	2	3	4	5
2. Nothing would be better than smoking a cigarette.	0	1	2	3	4	5
3. If it were possible, I probably would smoke a cigarette.	0	1	2	3	4	5
4. I would control things better if I could smoke.	0	1	2	3	4	5
5. All I want is a cigarette.	0	1	2	3	4	5
6. I have an urge for a cigarette.	0	1	2	3	4	5
7. A cigarette would taste good.	0	1	2	3	4	5
8. I would do almost anything for a cigarette.	0	1	2	3	4	5
9. Smoking would make me less depressed.	0	1	2	3	4	5
10. I am going to smoke as soon as possible.	0	1	2	3	4	5

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Using the scale below as a guide, write a number beside each statement to indicate how much you agree with it.

1-----2-----3-----4-----5-----6-----7
NOT TRUE SOMEWHAT TRUE VERY TRUE

- _____ 1. My first impressions of people usually turn out to be right.
- _____ 2. It would be hard for me to break any of my bad habits.
- _____ 3. I don't care to know what other people really think of me.
- _____ 4. I have not always been honest with myself.
- _____ 5. I always know why I like things.
- _____ 6. When my emotions are aroused, it biases my thinking.
- _____ 7. Once I've made up my mind, other people can seldom change my opinion.
- _____ 8. I am not a safe driver when I exceed the speed limit.
- _____ 9. I am fully in control of my own fate.
- _____ 10. It's hard for me to shut off a disturbing thought.
- _____ 11. I never regret my decisions.
- _____ 12. I sometimes lose out on things because I can't make up my mind soon enough.
- _____ 13. The reason I vote is because my vote can make a difference.
- _____ 14. My parents were not always fair when they punished me.
- _____ 15. I am a completely rational person.
- _____ 16. I rarely appreciate criticism.
- _____ 17. I am very confident of my judgments.
- _____ 18. I have sometimes doubted my ability as a lover.
- _____ 19. It's all right with me if some people happen to dislike me.
- _____ 20. I don't always know the reasons why I do the things I do.
- _____ 21. I sometimes tell lies if I have to.
- _____ 22. I never cover up my mistakes.
- _____ 23. There have been occasions when I have taken advantage of someone.
- _____ 24. I never swear.
- _____ 25. I sometimes try to get even rather than forgive and forget.
- _____ 26. I always obey laws, even if I'm unlikely to get caught.
- _____ 27. I have said something bad about a friend behind his or her back.
- _____ 28. When I hear people talking privately, I avoid listening.
- _____ 29. I have received too much change from a salesperson without telling him or her.
- _____ 30. I always declare everything at customs.
- _____ 31. When I was young I sometimes stole things.
- _____ 32. I have never dropped litter on the street.
- _____ 33. I sometimes drive faster than the speed limit.
- _____ 34. I never read sexy books or magazines.
- _____ 35. I have done things that I don't tell other people about.
- _____ 36. I never take things that don't belong to me.
- _____ 37. I have taken sick-leave from work or school even though I wasn't really sick.
- _____ 38. I have never damaged a library book or store merchandise without reporting it.
- _____ 39. I have some pretty awful habits.
- _____ 40. I don't gossip about other people's business.

Appendix B: Informed Consent Document

**UNIFORMED SERVICES UNIVERSITY
BETHESDA, MARYLAND**

This consent form is valid only if it contains the IRB stamped date

Consent for Voluntary Participation in a Non-Clinical Research Study

1. INTRODUCTION OF THE STUDY

You are being asked to be in a research study entitled “Attention Training in Smokers” at the Uniformed Services University of the Health Sciences (USUHS), Bethesda, Maryland. You have been asked to take part in this study because you are a smoker. Your participation is voluntary. Refusal to participate will not result in any punishment or loss of benefits to which you are otherwise permitted. Please read the information below, and ask questions about anything you do not understand, before deciding whether to take part in the study.

2. PURPOSE OF THE STUDY

The purpose of this behavioral research study is to evaluate a new method of influencing smokers’ attention, cravings and smoking. Results from this study may help researchers create more effective cessation (quitting) programs in the future. If you agree to be part of the study, you will be randomly assigned to one of two training conditions. You will not know which condition you are in. This is the normal procedure in this type of study. In previous research by other investigators, the attention training has been delivered on a desktop computer in a laboratory setting. This research has shown that these two conditions can influence smokers’ attention, cravings, and smoking differently. In this study, we want to see if we can deliver the training effectively on a PDA (a hand-held computer).

3. PROCEDURES TO BE FOLLOWED

You will attend up to 2 laboratory sessions in Building 28 at USUHS. The first laboratory session will last about 90 minutes and the second laboratory session will last about 60 minutes. You will first attend an orientation session. If you are eligible and you agree to be in this study, a research staff member will show you how to use the PDA. You will complete an assessment on the PDA. You will be asked to complete some brief questionnaires assessing your demographics (such as your age and income), your smoking, and your personality. You will be given a smoking diary and asked to record the number of cigarettes you smoke each day for the next week. You can smoke as much or as little as you like during the week.

You will be asked to carry a PDA around with you for 1 week. The PDA will beep you at random times during the day (about 4 times each day). After the PDA beeps you, you will be

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Subject’s initials _____ Date _____
Witness initials _____ Date _____

asked to respond to a series of questions which ask you how you are feeling at that time. You will perform a reaction time task on the PDA. Each PDA assessment should last about 10 minutes in total.

At the end of the study, you will be asked to attend a second session at which you will return the PDA and the smoking diary. You will complete an assessment on the PDA. You will also perform a brief task in which we will measure where you look using a device that measures eye positions. For this task, you will wear a spectacle with a mini camera, and a light recording device on a hip-pack, for a brief duration.

At both the orientation and second sessions, you will be asked to provide a breath sample and a saliva sample. The breath sample and the saliva sample will help the researchers find out how much you have smoked. At the orientation session, the level of carbon monoxide in your breath must be above a certain level in order for you to be eligible for the study. Your craving for cigarettes will also be assessed.

When your participation in the study is over, you will be offered self-help materials for quitting smoking and a referral to smoking cessation programs.

4. NUMBER OF PEOPLE THAT WILL TAKE PART IN THIS STUDY

Up to 96 individuals are expected to participate in this study.

5. AMOUNT OF TIME FOR YOU TO COMPLETE THE STUDY

Participation of this study will require in total about 6 and a half hours of your time over a period of about 1 week.

6. ELIGIBILITY AND PAYMENT FOR BEING IN THIS STUDY

Participation:

Civilians and military personnel may participate in this study. Federal civilians and military personnel must provide the investigators with a signed Statement of Approval form.

Compensation:

Civilians may receive compensation for their participation in this study. Military personnel cannot receive compensation for their participation.

Non-federal civilians will receive \$20 for completing the orientation session (even if ineligible), and \$20 for completing the second laboratory session. Non-federal civilians will receive \$2 for

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Subject's initials _____ Date _____
Witness initials _____ Date _____

each PDA assessment that they complete. They will also receive \$5 for each day (except the final day) that they contribute data to the study, up to a maximum of 7 days. If a non-federal civilian completes all scheduled PDA assessments, they will receive approximately \$131 (\$20 (orientation session) + \$35 (days completed in study) + \$20 (second laboratory session) + (\$2 x 28) (PDA assessments)).

Federal civilians will only receive compensation for the laboratory sessions and the PDA assessments that occur during non-duty hours. For example, if a federal civilian completes the orientation and second laboratory session during non-duty hours, and completes 1 PDA assessment per day during non-duty hours, they will receive \$89 (\$20 (orientation session) + \$35 (days completed in study) + \$20 (second laboratory session) + (\$2 x 7) (PDA assessments)). A check will be mailed to civilians following completion of the study.

7. POSSIBLE RISKS OR DISCOMFORTS FROM BEING IN THIS STUDY

The risks or discomforts from being in this study are expected to be minimal. There are no known risks associated with completing the laboratory assessments or the PDA assessments. There is no reason to believe that your smoking will be increased by participation in the study.

You may refuse to answer any question that makes you feel uncomfortable. If you have concerns after completing the questionnaires, you are encouraged to contact your doctor or the study chair.

If something in this research makes you uncomfortable or upset, you may choose to stop taking part in this research at any time without loss of benefits; you may contact the investigator for referral. If the investigators note any distress or anxiety associated with the research, you will receive referrals, if appropriate.

8. POSSIBLE BENEFITS FROM BEING IN THIS STUDY

Some participants may reduce their smoking over the course of the week. Some participants may experience reduced cravings. However, no benefit can be guaranteed.

The information we learn may help us develop better smoking cessation programs. Therefore, smokers may benefit from what is learned. This may be beneficial to society.

9. CONFIDENTIALITY/PRIVACY AND HOW YOUR IDENTITY AND YOUR RESEARCH RECORDS WILL BE MAINTAINED

All information you provide as part of this study will be confidential and will be protected to the fullest extent provided by law. Your responses to our laboratory and PDA assessments will be maintained in a locked filing cabinet or on a password-protected computer in lab offices in the Department of Medical and Clinical Psychology. All records related to this study will be

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Subject's initials _____ Date _____
Witness initials _____ Date _____

accessible to those persons directly involved in conducting this study and members of the USUHS Institutional Review Board (IRB), which provide oversight for protection of human research volunteers. In addition, the IRB at USUHS and other federal agencies that help protect people who are involved in research studies, may need to see the information you give us. Other than those groups, records from this study will be kept private to the fullest extent of the law. Scientific reports that come out of this study will not use your name or identify you in any way.

The breath sample you provide will allow us to measure carbon monoxide (CO) levels in your breath. This will allow us to measure how much you have smoked. We will use a standard CO monitor (Vitalograph, Lexena, KS) according to the manufacturer's instructions. Data on your CO levels will be stored on a password-protected EXCEL spreadsheet on a computer in Room 113 of Building 28. The password is only known to the research staff.

To prepare for the saliva sample, you will be asked to refrain from eating and drinking for 10 minutes before sampling. You will be offered a moist towelette to clean/wipe your hands/mouth. Using gloves, the research assistant will open the vial and give you the cotton roll. You will be asked to place the cotton piece in your mouth and to gently roll it in your mouth for a whole minute to saturate with saliva. You are requested to place most of the cotton piece on the edge of your mouth and re-insert it to the vial without touching the vial. Using gloves, the research assistant will tightly replace the cap on the vial.

The saliva samples will be stored in a freezer (-80F) in Building 28 for up to three months. Batches of saliva samples will be sent to Salimetrics, Inc. (www.salimetrics.com). Salimetrics, LLC, will perform an assay (a test) on each sample to determine the level of cotinine in the saliva. Cotinine is a breakdown product of nicotine and tells us how much you smoked during the past few days. No other tests will be performed on the saliva samples.

Only the study researchers will have access to the saliva samples. The samples are labeled with the participant study number (and visit number); only the research staff know the linkages between study numbers and participants. Thus, confidentiality is maintained during storage and distribution. The shipping procedures follow the U.S. Centers for Disease Control (CDC) guidelines for transport of biological specimens. Once the cotinine assay is performed, Salimetrics, LLC will destroy the samples. Because you are free to drop out of the study at any time, you can request that your saliva samples are destroyed. Saliva samples will only be stored at USUHS.

10. CONDITIONS WHICH YOUR PARTICIPATION IN THIS STUDY MAY BE STOPPED WITHOUT YOUR CONSENT

The investigator may stop you from taking part in this study if being in the study is unsafe or dangerous to you or if you lose your right to receive medical care at military hospitals. The investigator may also stop you participating if you experience difficulty in following the

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Subject's initials _____ Date _____
Witness initials _____ Date _____

procedures.

11. IF YOU DECIDE TO STOP TAKING PART IN THIS STUDY AND THE INSTRUCTIONS FOR STOPPING EARLY

You have the right to withdraw from this study at any time. If you decide to stop taking part in this study, you should tell the principal investigator as soon as possible; by leaving this study at any time, you in no way risk losing your right to medical care.

12. RECOURSE IN THE EVENT OF INJURY

If at any time you believe you have suffered an injury or illness as a result of participating in this research project, you should contact the Director of Human Research Protections Programs at the Uniformed Services University of the Health Sciences, Bethesda, Maryland 20814-4799 at (301) 295-9534. This office can review the matter with you, can provide information about your rights as a subject, and may be able to identify resources available to you. If you believe the government or one of the government's employees (such as a military doctor) has injured you, a claim for damages (money) against the federal government (including the military) may be filed under the Federal Torts Claims Act. Information about judicial avenues of compensation is available from the University's General Counsel at (301) 295-3028.

CONTACT FOR QUESTIONS OR PROBLEMS

If you have questions about this research, you should contact William Kerst, the person in charge of the study. William's number at USUHS is 301 295-1520. Even in the evening or on weekends, you can leave a message at that number. If you have questions about your rights as a research subject, you should call the Director of Human Research Protections Programs at USUHS at (301) 295-9534. She is your representative and has no connection to the researcher conducting this study.

SIGNATURE OF RESEARCH PARTICIPANT OR LEGAL REPRESENTATIVE

You have read (or someone has read to you) the information in this consent form. You have been given a chance to ask questions and all of your questions have been answered to your satisfaction.

BY SIGNING THIS CONSENT FORM, YOU FREELY AGREE TO TAKE PART IN THE RESEARCH IT DESCRIBES.

Participant's Signature

Date

CO72JV-02 (13Jul10)

Subject's initials _____ Date _____
Witness initials _____ Date _____

Subject's initials _____ Date _____
 Witness initials _____ Date _____